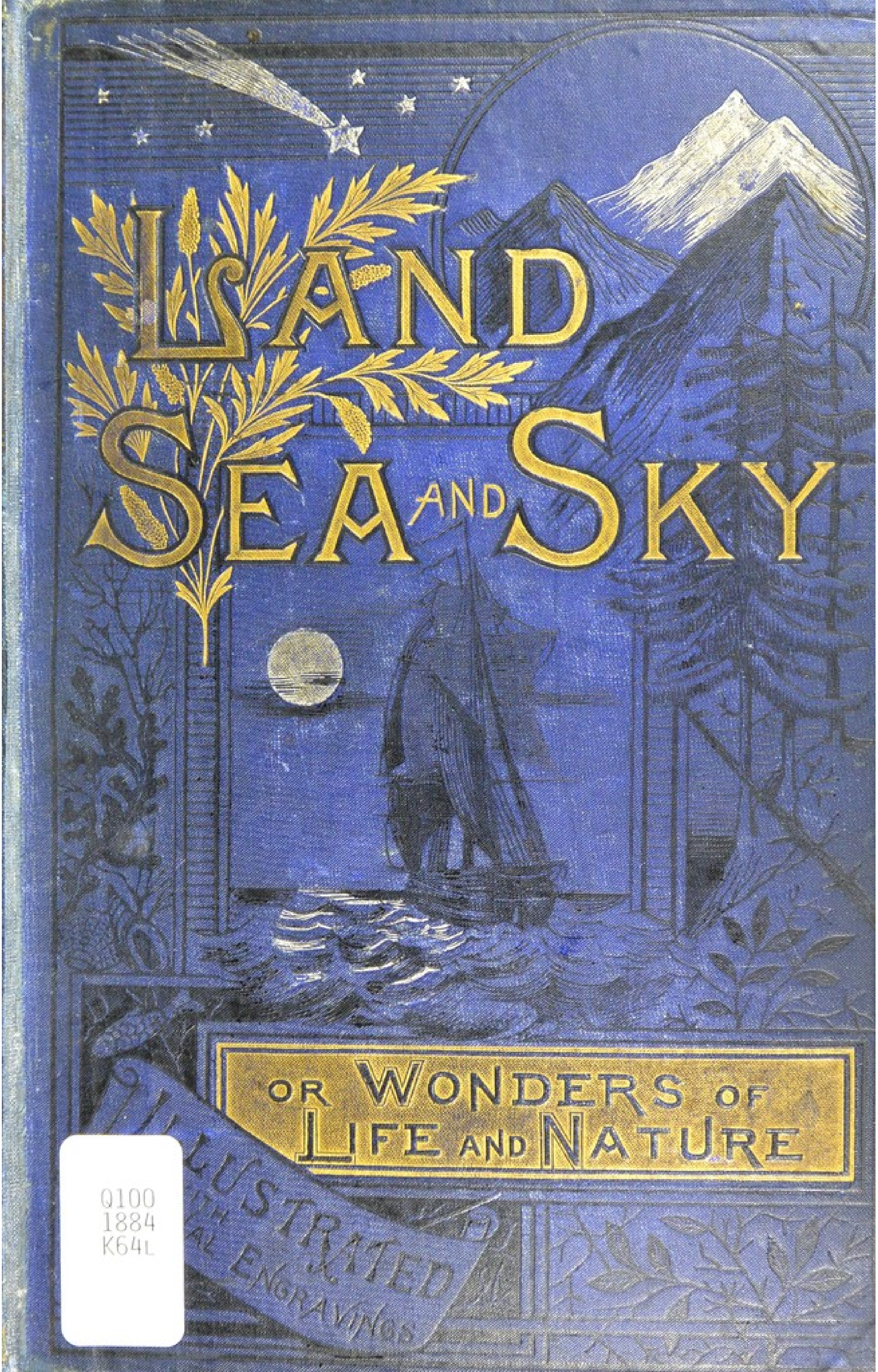
LAND
SEA AND SKY
OR WONDERS OF LIFE AND NATURE
ILLUSTRATED WITH ... AL ENGRAVINGS

LAND, SEA AND SKY,

OR,

Wonders of Life and Nature.

A DESCRIPTION OF

THE PHYSICAL GEOGRAPHY AND ORGANIC LIFE
OF THE EARTH.

Translated from the German of Dr. Herman, J. Klein and Dr. Thomé,

BY

J. MINSHULL.

WITH THREE HUNDRED ORIGINAL ILLUSTRATIONS.

London:
WARD, LOCK, & CO., WARWICK HOUSE,
SALISBURY SQUARE, E.C.
NEW YORK: 10, BOND STREET.

[1884]

PREFACE.

THE title of the book now offered to the public tells its own story, and, as it seems to the writer, suggests its own *raison d'être.* The very width and comprehensiveness of the subject—Land, Sea, and Sky—will prevent any one from looking upon it as a mere technical work, planned and executed as a text-book intended to meet the needs of the specialist, whether student or professor. There are already in existence a great number of excellent books filled with the crabbed but necessary technicalities of botany, physical science, astronomy, and zoology, with which the present volumes will not clash either in the way of repetition or contradiction. Its aim, if humbler, is yet wider than any of these; it speaks to a larger public, and appeals to every kind of sympathy with the wonderful works of nature surrounding us, instead of pointing to one definite and isolated branch of study.

It is one of the anomalies which strike foreigners who occasionally turn aside to study the contradictory elements which make up our national character, that the love of home and the love of travel seem to exist within the hearts of Englishmen side by side; both being strong, passionate, and instinct with almost equal force and vitality. So that a book which speaks to the Englishman of *Land,* speaks to him first of wide-spread responsibilities of empire over different races and in distant climes; of the great heritage of glory bequeathed to him in the past, not only by conquest, but by scientific explorations; and by the intense sympathy of which he is conscious, while reading of the deeds of his forefathers in the distant homes which they have won for themselves, he feels that their spirit is still alive within him; that he, too, is stirred by that love of home and country which fosters rather than represses the keen desire to see the wonders of foreign lands, the joy of travel and adventure, the northern love of solitude, the thrill of measuring man's strength and endurance against dangers of every kind, known or unknown, the pleasure of the chase, the winning from alien races that confidence so often granted to the solitary white man who speaks the truth and knows no fear.

And there is another class of minds, for whom this work should have peculiar attractions; a class which, without possessing any great gifts of health and strength, unsupported by physical energy or animal spirits, uninspired by any thirst for adventure, has yet done good service to their country and the world at large as some of our most dauntless explorers. Urged on along their toilsome path by the ardent love of nature, the scientific traveller, botanist, naturalist, or geographer has persevered through weakness, weariness, and ill-health, supplying by indomitable pluck, and by the irresistible desire of reading the open secret of Land, Sea, and Sky, the shortcomings and feebleness of his physical frame.

And if this is the case with the first part of our subject, is there not even a stronger spell to every English heart in the word *Sea?* From the hour when—more truly than the poet thought in his unconscious divination of the past—"Britain first arose from out the azure main," the roar of the surf or the pleasant plashing of blue waves upon our coast has been in the ears of English boys a music sweeter and truer than any voices of the Sirens, and has called them forth to venture out into the trackless deep, to dare its perils, endure its hardships, fathom its depths, learn something of its hidden secrets, and win much of its buried treasures.

Or if, careless of foreign travel, and untouched by the spell owned by most of those who dwell within this isle "set in the silver sea," some readers may care little for the first or second parts of our subject, there remains yet the *Sky*, which each one may study without going far beyond the threshold of his home. The wonders of the heavens, with their hieroglyphic scroll of stars; the silent beauty unveiled night and morning, in obedience to laws of which we are beginning to catch some glimpses, and of which we would fain know more; the world of stormy winds and changing cloud, the home of tempest, rain, and snow, has already attracted many a noble mind and reverent intellect to seek out the mysterious laws of their being, and to be rewarded by great and glorious discoveries.

But, while we have perhaps said enough in justification of our hope of attracting and repaying a large circle of readers, we may be allowed to enter more fully into the method employed in treating of these different parts of our subject, and the results to which we hope the present work may lead. We have, then, in the three sections of our work, endeavoured to place before the non-scientific reader something like a general history of our world, considered in its three great elements of Land, Sea, and Sky. Beginning with the earth as a planet, we have spoken of its various revolutions, its shape, and size; and then, considering it as the world in which we live, we have dealt with the formation of its continents and islands, the great divisions of desert and mountain, tundra, marsh, and ice field; of the hidden forces beneath its surface, central heat, volcanic disturbances, land-slips, and gradual and sudden displacements of land and water. Later on we have completed our story of the land by writing of its recent division into zoological and geographical regions, taking each division separately, with its peculiar forms of animal and vegetable life, adding wherever necessary explanations as to the uses and properties of plants, and the methods employed in turning them to account and preparing them for the markets, and occasionally giving a list of the several animals, birds, fish, or plants specially restricted to the region in question.

In writing of the Sea, we have spoken first of its volume, and the composition of its waters; its depth and temperature; the wonders of its tidal waves and currents, the Gulf Stream—its whirl-pools, waterspouts, and coral reefs; and, as all rivers rise from the ocean, we have included in this part of the work several chapters treating of the waters of the continents, mountain springs, artesian wells, mineral springs, and subterranean watercourses. Rivers, with their waterfalls and spreading deltas, lakes, mountain tarns, and marshes find their place here, and we have devoted more time to any which seemed to deserve greater attention, such as the great inland lakes of the Caspian and the Aral, or the legend-haunted waters of the Dead Sea.

In our last section we have spoken of the Sky, not so much with reference to astronomy, but as the element in which our world lies enfolded; of its atmospheric temperature and pressure, the course of the winds, the moisture of the air, cyclones, tornadoes, thunder-storms and electric phenomena, and the beautiful aurora borealis.

It has been our aim to write of these things clearly and simply, avoiding technical language as much as possible, and endeavouring to give such a general knowledge of the subject as is compatible within the limits we have prescribed for ourselves. We have tried to shew by what slow, uncertain steps the truth was reached; how much of past error concerning our present home and its three great elements had to be unlearnt before we attained even to our present limited standpoint of knowledge—a lesson which teaches us humility, sympathy for past mistakes and ignorance, and animates us with a confident hope for the guidance of our future researches, that to all patient seekers more knowledge shall be revealed. We have in each part of our subject carried our story down far enough to include the latest additions of modern research—a process which necessarily involves some occasional contradictions between the last word of science and its last but one. In such cases it is not our province to pronounce an opinion, or do more than lay the conflicting theories before our readers.

Our task has been rendered easier by the admirable illustrations so freely scattered throughout the volume, which either attract the eye and awaken the desire of reading the history of the beautiful or curious forms there represented, or appear as explanations of the letterpress, making clear in a moment what has taken many and carefully chosen words to describe. We think, then, that we have justified the appearance of a new book in this book-laden world, and will bid our readers good-bye with some words which seem to sum up the thoughts likely to be suggested by our title-page in the minds of a circle of English readers trained in the best traditions of our country and our faith.

Land, Sea, and Sky! what mystery and wonder
  Lie hidden in the old, familiar sound!
From surging wave and roll of mighty thunder
  To the white daisy nestling on the ground.

Land, with its poison swamps and sunny meadows,
  With flowers adorned, with earthquakes torn and rent;
Glad song of birds within the woodland shadows,
  Growl of the wild beast's savage discontent.

Sea, with its silver calms and stormy terror,
  Deep currents tracking out their hidden way
Through moon-drawn billows, without pause or error,
  'Mid coral reef, still depths, and flashing spray.

Sky, where the light waves break in sunset splendour;
  Where fierce winds grapple and blue lightnings play;
Where night brings golden stars and moonlight tender;
  Where o'er the pole flashes the aurora's ray.

Be ours the faith to con the tangled story,
  And look beyond the mystery of pain,
Till God, Who loves us, in His home of glory,
  Teach us to read the unsolved riddle plain

In that fair land, whence pain is driven for ever,
  By the still waters of the crystal sea;
Beneath that sky, whose fadeless splendour never
  Borrows from sun or moon its radiancy.

And ours the life of prayer, and love, and duty,
  Which brings us nearer, as the swift years fly,
God helping us, unto heaven's cloudless beauty—
  Unto the better Land, and Sea, and Sky.

JANET MINSHULL.

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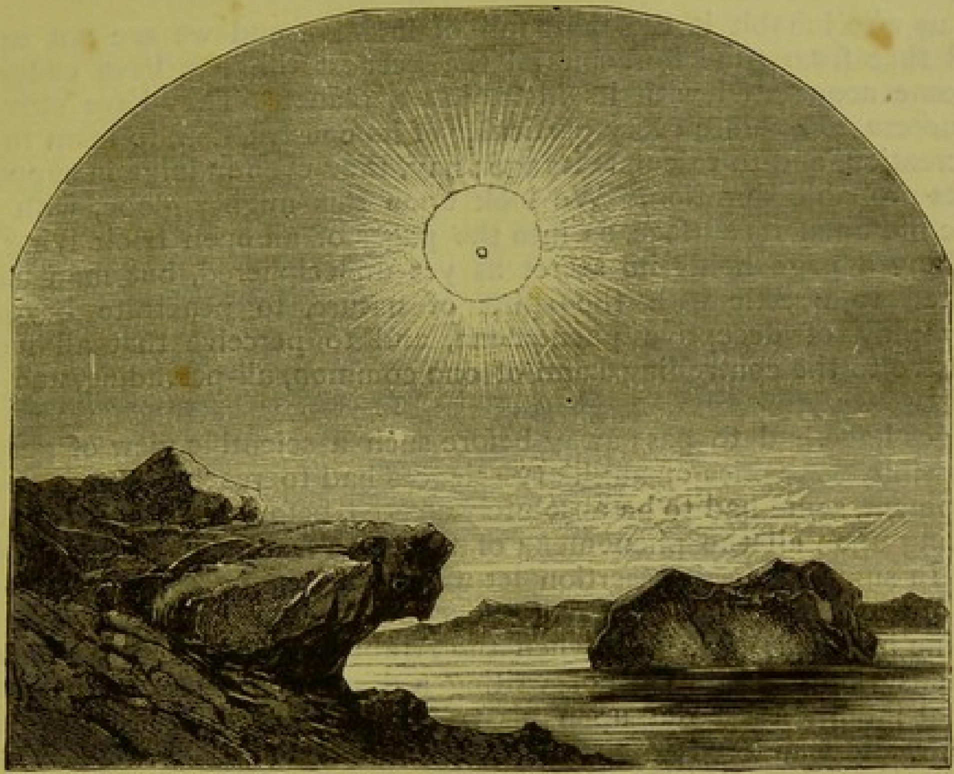


Transit of the Earth across the Sun, as seen from Mars

LAND, SEA AND SKY.

CHAPTER I.

INTRODUCTORY.

A STAR among countless stars, this world of ours pursues its majestic course round the sun, whence it draws its light and heat. It is now an indisputable fact that the great globe, when looked upon from a remote distance, presents the appearance of a planet; such an appearance as that which we admire in the beautiful evening star.

If it is said that no one has ever been permitted to take up a standing point outside our sphere, whence he could pronounce upon it from without, we answer that such testimony is by no means necessary in order to gain a clear idea of the position of our earth in reference to the universe. A series of phenomena, the comprehension and explanation of which take rank among the most glorious triumphs of the human intellect, furnish us with important information as to the part played by the earth in the great organism of world-systems.

It has been proved that the terrestrial globe on which we live is by no means, as it was for thousands of years commonly believed to be, the chief and central part of the universe; but that, on the contrary, it is in comparison with the world-systems around it, a mere grain of sand in the desert, or a drop of water in a shoreless ocean. But, granting this insignificance of our earthly planet when measured against the mighty systems, it must naturally be for us who inhabit it the most full of interest, and we are not surprised to find that from time immemorial the keenest thinkers have endeavoured to become acquainted with its history as a planet. They have striven, and with success, to explore every particular of its construction, to learn the mode of its creation, and to calculate its age; nay, they even indulge in suppositions as to its probable duration. We look upon this mighty globe, with all the organic life upon its surface, as into the pages of an open book lying before us. Many a page holds its secret as yet undeciphered, but man has been permitted to wrestle with the spirit of nature, to penetrate beyond the illusory play of deceptive phenomena, and to perceive that all nature is submissive to the controlling hand of one common, all-pervading, and eternal law.

Ages have had to pass away before such a scientific view of geography was possible. A series of auxiliary sciences had to reach a certain degree of development, some had to be absolutely created, before any one dared to think of looking upon all the phenomena of the earth from one common point of view. In support of this assertion let us cast a hasty glance back to certain stages of the history of this "earth-science" which we call geography.

Nine hundred years ago, when the Arabian traveller, Abdallah Ahmed Mokaddasy, formed the plan of writing a description of Moslem lands, and with that intention set out upon his travels, he started from the Straits of Gibraltar, and wandered to the distant boundaries of India. Spurred on by his enthusiasm for scientific discovery, the indefatigable traveller journeyed over great part of the then known civilised world, encountering on his way many a hair-breadth escape from danger. "I have," he writes, "studied, while on my travels, theology and the humanities, and I have also taught these sciences. I have played the devotee and the ascetic, have preached in Christian pulpits on Good Friday, and called the faithful to prayer from the minaret. I have led the prayers in mosques, and officiated in cathedrals. I have frequented universities, defended party against party in popular assemblies, and taken part in the learned dialectics of philosophers. I have shared the polenta of the dervish, the hard fare of the sailor, and the unleavened bread of the caravan traders. Many a night have I been driven from the mosque, lost in boundless steppes, wandering through desert places. At one time strict as a Pharisee, at another eating openly of unlawful and ill-gotten food. I have made one of the pilgrim train of penitents on their way to Lebanon, and have mingled freely with viziers and princes. I have possessed slaves, and it has been my lot to carry the slave's basket on my head. More than once I have narrowly escaped drowning. I have been in caravans which have fallen a prey to robbers, and I have myself joined with robbers on the open highway. I have sold wares in the market place, languished in prisons, and been arrested as a spy. I have borne arms against the unbelievers, and have done duty as sentinel in frontier garrisons."

So says Abdallah the Arabian; but when we come to investigate the results of these weary wanderings, which took up more than half a human life, we find that the traveller's information, while it contains much that is interesting and even valuable in a scientific point of view, does not convey to us the faintest idea concerning the formation of the earth's surface, or any accurate account of the relative positions of the countries visited. Now, how are we to explain this deficiency and incompleteness? Was this eager traveller, who tells us that he has again and again wandered ten miles from his caravan merely to learn the name and size of some little town, incapable of under-standing the elementary questions of geographical description? or was he careless of these proportions and relative estimates, which, as we know, are the necessary foundation of all accuracy? Neither the one nor the other. The most strenuous exertions, the most self-sacrificing toil of the dauntless explorer, were of necessity valueless in reference to these fundamental problems, because the essential conditions necessary to the existence of scientific geography did not themselves exist in his day.

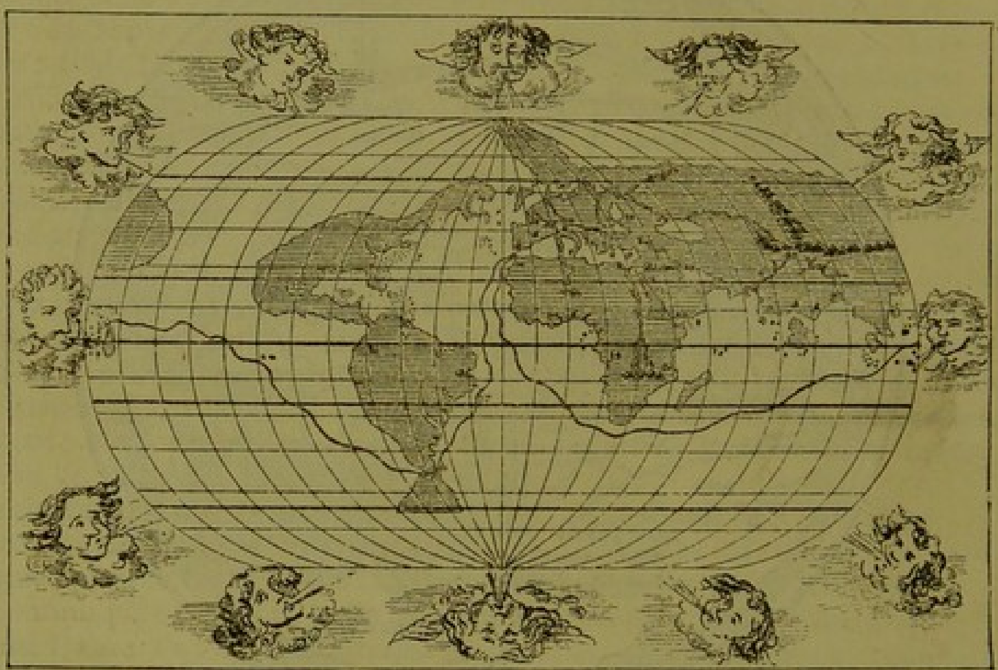
After this time the Arabians earned the highest place in the perfecting of this science. When we find them, fifty years after the death of their Prophet, dispersed as far as the extreme western boundary of Africa, we find, together with their world-famed nomadic instinct, the spirit of investi-

Map of the World in the 14th Century

gation devoting itself to explore the earth, its configuration and organic productions from the Euphrates to the Guadalquiver, from Kashgar and Cabul to the south of central Africa. From their day the scientific principle gradually asserted itself, slowly and painfully, sometimes misunderstood in its aim and tendency, or crushed and silenced by the rude hand of force, but still advancing, until in the fifteenth century the greatest wealth of material of every kind, the richest stores of knowledge necessary for the establishment of physical geography, which the history of civilisation ever records, were opened to the human race.

In 1490 the learned professors of the University of Salamanca were gravely disputing with Columbus, and bringing forward sophism after sophism to show that the earth was not a sphere, but a plane. Thirty years later the greater part of the Atlantic shores of America, as far as Patagonia, was roughly outlined on every map. Together with a right view of the spherical form of the earth, Columbus, it must be admitted, reckoned the circumference of the world to be less than it was by the whole breadth of the Pacific. He supposed that two-thirds of its circumference were known to the ancients, and he hoped to sail round the remainder in his journey westward towards the eastern coast of Asia.

On approaching the island of Cuba, Columbus thought that he was near to the coast of China, and he sent a baptized Jew, Luis de Torrez, to land, because the man was well versed in Hebrew, Arabic, and Chaldaic, languages which were commonly spoken in the Asiatic trading towns. It was the same idea of the vicinity of the eastern coast of Asia which induced the daring Genoese to steer a westerly course in the latitude of the Canaries, a course which must have led him through the warm waters of the Gulf Stream to Virginia in North America. The flight of some parrots past his ship on the 7th of October, 1492, decided him to strike a south-westerly course, and led



Map of the World, by Giovanni Agnesi, in 1548, with the Course of the Winds.

him, five days later, to the discovery of the Island of San Salvador. Never, surely, has the flight of birds had mightier influence on the destinies of our race; for who can fathom the difference to the development of culture and progress if North America had received a Spanish instead of an English population? Columbus' mistake was no fault in principle; and when, in 1497, the great Vasco de Gama and his bold Portuguese guided the keel of their ship through her fearful voyage across the waters of a sea unknown to Europeans, it was permissible to believe that India stretched out eastward to the shores of the Atlantic Ocean. It was Martin Behaim, of Nürnberg, who first arrived at the conviction that a great sea rolled between the East and West Indies, and he boldly traced upon his famous map of South America that passage across the western ocean which Magalhaen actually found in 1520.

We must not linger more in detail over the great voyages of discovery which laid open to future generations the South Seas; we would only point out how the wider expanse of horizon unfolded to the physical vision strengthened and widened also the mental sight, and how geography assumed more and more the aspect of a science. Thus we find Columbus, in his first voyage of discovery, devoting the greatest attention to the natural phenomena around him; the changes of temperature, the atmosphere and qualities of the sea, the deviations of the compass; nay, he fancied that in the western hemisphere the earth presented a more swollen appearance, and his lively imagination ascribed the existence of the Lesser Antilles to the effect of an Atlantic current flowing from east to west.

However far from the truth these and similiar fancies of the great discoverer and his contemporaries might have been, they served to show the new spirit which was pluming its wings and making ready for flight from the gloomy regions of shuddering forebodings to the light of knowledge and truth.

THE SHIP OF COLUMBUS.

The almost parallel advance made in astronomical science, the right view of the construction of the solar system, worked with the happiest effect on the method in which the study of nature was approached, and helped forward the scientific conception of terrestrial phenonmena. Light, heat, and magnetism were eagerly questioned with reference to their bearing on the earth's organic forces. Especially was the new mysterious power of earth-magnetism welcomed with delight, partly because it was hoped by its means to determine the position of ships on the ocean. In the year 1634, Hellibrand was the first to give unhesitating testimony to the change of direction taken in the course of the year by the magnetic needle, and to show that the end which pointed to the north veered slowly westward. Now, for the first time, life and motion were recognized in the net of magnetic forces stretched around the earth, and at the end of the seventeenth century we find Halley presenting a petition to the English Government for the chartering of a vessel to make investigations as to the direction of the magnetic needle on the coast of the English colonies of North America.

At the same time, thermometrical observations were industriously carried forward, and, more important still for physical geography, the idea of applying the newly invented barometer to the measurement of altitudes was openly mooted. When the illustrious Pascal sent his brother-in-law Perryer with a barometer up the Puy-de-Dome to see the quicksilver sink lower than it stood in the plain, it was clear to the profound mathematician that the decrease of inches and lines marked by the barometer from the crest of the mountain would give the correct proportion required for determining the height of the mountain above the level of the sea, and that a new weapon was thus placed in the hands of scientific geography, the importance of which was only equalled by the scope of its application.

We are apt sometimes to feel astonished when we hear that the Romans, even in the time of their highest development, knew absolutely nothing of the central direction of the Apennine chain, which forms, so to speak, the backbone of Italy; and that they had not the faintest conception of the general formation of the Alpine ranges. But if we come nearer to our own day, and that by fifteen hundred years, we find that, even in the beginning of the seventeenth century no one had any accurate idea as to the altitudes of the Alpine peaks; and that it was a frequent subject of dispute whether Mount St. Gothard was 3,000, or 10,000, or 30,000 feet high. The barometrical measurements speedily put an end to this state of things; and when, later on, Humboldt supplemented his series of measurements of altitudes by section charts of whole countries, the vertical configuration of the locality was clearly established. And so we gradually approach our own times, in which physical geography takes its own distinguished place among the many branches of natural science.

For it is not only that wide stretches of hitherto unexplored country have been laid open to the glance of the civilised world, not only that rivers, lakes, and mountains have been discovered, and the courses of streams laid down with greater accuracy upon our maps, but rather and chiefly that the materials of all kinds heaped around us in such lavish profusion are all looked upon from one common point of view, and that the cause and effect of each separate detail are placed face to face. In past ages geography was nothing, and could be nothing, but an accumulation of separate facts, and the earth was looked upon as an instantaneous creation, rather than as a growth, for the laws and conditions of which it was necessary to investigate the relationship in which each separate part stands to the rest. But opinion was gradually awaking: already Karl Ritter wrote as follows:—"Scientific geography looks upon our earth by no means as a mere lifeless aggregate of unorganised nature, or, as Herodotus expresses himself, a globe turned at the lathe; but rather as a genuine, specially organised body, still in process of development; carrying within itself the life-germs of yet further growth with the growth of centuries and thousands of years. Under this aspect it acquires unity; by this principle of inward life it becomes a coherent whole, capable of a systematic unfolding and development of its great system; it becomes also a school of culture for the human race, and an essential link in the chain of science."

It is true that Ritter himself never gave a description of scientific geography in the full sense of the word; his pioneering labours were necessarily restricted within narrower limits—in a certain sense, to the foundation of the mighty edifice which was to arise before the eyes of the coming century. In saying this we do not for an instant seek to lessen the rare merit of the great geographer, we simply point out that at the time when Ritter lived it was impossible to do more than he did. For scientific geography is dependent, as few other branches are, upon the development of a whole chain of kindred sciences, and is forced, whether she will or no, to stop short in her advance when she is deserted by her drilled auxiliary forces. No science is so incapable of solitary advancement as is physical geography. When the astronomer tries to throw more light upon the complicated problems of the disturbance theory, or the physical student investigates the phenomena of polarisation—when the chemist undertakes the analysis of various elements, or the geologist examines the laws of the stratification of rocks, each searcher is almost independent in his own domain of the advance of any other branch of science. But, on the other hand, when a bold traveller strikes across the never-trodden path of some unknown region, the gain which scientific geography is able to gather from his explorations depends in a very great degree upon the development of astronomy, meteorology, geology, etc., so far as these sciences enable him to test the observations he has made, and to avail itself of them for future deductions. And if we take into account those branches of the subject which have to do with organised nature, and attempt to understand and explain on scientific principles the distribution of living beings over the surface of the earth, we shall find no difficulty in admitting that the advance of physical geography is intimately connected with the development of natural science; and that for that very reason it was impossible for the mere idea of scientific geography to exist in former times.

At first geography attempted nothing more than an unconnected gathering together of descriptions of foreign lands and curiosities; by degrees it advanced towards some more or less systematic statistics of names and figures; afterwards—and here Karl Ritter led the way—it recognised and commented upon the connection between the nature of a country and the history of its inhabitants. Then, and not till then, was scientific geography able to come forward, and, hand in hand with the natural sciences, to investigate the separate particulars of the earth's formation, and to establish its significance for the unity of all terrestrial phenomena, organised as well as unorganised.

A few examples will suffice to throw a clearer light upon the mission and task of modern physical geography. A considerable portion of the surface of our earth consists of deserts or sandy wastes, and of these the great desert of Sahara is the commonly accepted example. In former geographical treatises we find merely the position of the desert, estimates as to its surface extent, the number and situation of its oases, the names of a few mountain ranges which come within its boundaries, and probably to lend an interest to the whole, a few anecdotes concerning the great heat of the district, and the risks incurred by travellers from robbers and other dangers. Modern geography, on the other hand, sees in the desert an integral part of the earth's organism; points out that its existence is due to no mere accident, but is the effect of the past and present distribution of land and water, and of the position of the zone of calms; it shows the desert still in process of formation, in so far as centres of sand radiation still exist; it solves for us the problem of the existence of springs in the oases, showing that the absence of rain has nothing to do with the question, and that the meteoric water is quite sufficient to keep up the springs in these low-lying districts. It points out also, by the help of meteorology, how destructively one continent works upon another; and, extending its circle of observation to the earth's inhabitants, it establishes the connection between the formation of the land and the direction taken by civilisation—nay, even its influence upon peculiarities of language.

It is thus that physical geography breathes life into the dead surface of our planet, and lends to the silent picture traced upon the map a language which the cultured mind can understand. For all our best modern maps show signs of the effort made to correspond with this higher view of geography. Where, for example, the surface of the sea used to be represented as a blank open space encircling the land, and nothing was to be noticed upon it, except perhaps the absence of islands, we see now the results of the sea soundings carefully indicated, and the lines of equal depth afford, by their more or less exact correspondence with the contour of the coast line, valuable information as to the construction of the land itself. If in some places the inequalities of the bottom of the sea tell us of some long severed connection between continent and continent, so in other and widely separated lands the appearance of kindred forms of animal and vegetable life speak of lost continents now engulphed beneath the waves. Where the stormy Indian Ocean now rolls its troubled waters, and the deep sea soundings give a depth of many thousand yards, there stood in all probability, at the time when the extinct volcanoes of the Eifel and of central France were sending out their torrents of lava, and the primeval forests of Europe re-echoed with the hollow roar of subterranean forces, a wide-stretching continent, some of the relics of which still exist in the great islands of Madagascar and Ceylon. Whatever may have been the cause which swept away this continent from the surface of the earth, the lost *Lemuria*, as the vanished country is called, is but one of the many stations which come within the circle of vision of physical geography, where, in the course of the world's development, organic life advanced to high degrees of culture. And as to the manner in which the development and distribution of organic life is effected by the position and extent, the height and depth of the mainland, geography brings forward numerous examples.

We must not at present dwell upon this topic, but it is advisable even on the threshold of our subject to point out that the same science shows in how great a degree the character of the land affects the character of its inhabitants. We need not go far afield in support of this assertion; it is certainly true that no pre-eminently great man has at present arisen in the tropics, where the human race seems crushed beneath the overwhelming force of geographical and climatic influences, but we have a striking example nearer home.

Let us turn to the north-west shores of Germany, and there, in the islands of North Friesland, we see how geographical influences can mould the character of a people. North Friesland was once one undivided tract of land, until England and France were rent asunder, and the wild rush of the incoming sea tore away piece after piece from Friesland. We do not know how long the deadly duel between man and ocean has been prolonged; we know only that never in the world's history has there been a struggle so fierce and obstinate, so heroic and so hopeless. On one hand the primeval ocean, ever on the watch to steal a march upon its foe, ruthlessly destroying every obstacle to its advance, and on the other a race of men inured to daily struggles with a formidable enemy, full of courage and resolution, ever ready to defend home and wife and child against the aggressor. And now look at our North Frisian, stern and strong-willed, resolute in face of danger, obstinately clinging to old tradition, as to the ground on which he treads. Has not the thunder roar of the surf schooled him into a hero? Has it not strengthened his heart and character, and made him morally and physically the man he is? It would be easy to bring forward further examples from Europe; we could, for example, show how, apart from certain ethnological peculiarities, the Frenchman the Dutchman, and the Englishman are fashioned to what they are by the geographical influences of their respective countries. But it is unnecessary to accumulate the evidences on this point; everywhere around us we see indisputable proofs that the development of culture depends upon geographical circumstances, and changes with them. At the time when central Europe amid her frozen glaciers gave shelter to a scanty population, whose descendants are probably known to us as the Esquimaux, human civilisation blossomed in the south-east. To-day the deadly breath of scorching winds sweeps over the ruins of Babylon; and civilisation, retreating from the districts where, in the childhood of our race, she put forth such glorious blossom, turned westward, crossed first the Atlantic, and afterwards the wide stretch of the Pacific Ocean.

In earlier and more uncritical times, many a legend was current among men about the fabled island of Atlantis, a fair land, with gracious and beautiful inhabitants, lying, it was said, somewhere in the western ocean. To-day, however, our historians and geologists join with the students of the younger science of physical geography in rejecting the fabulous story. Culture has reached us, not from the West, but from the East. It was in the fertile valleys of Asia that man rose first from barbarism to higher views of life. It was from that starting-point that civilisation set out upon her course, pressing westward, and after many centuries taking up her abode in Europe, which presented the most favourable conditions for her further development. But Europe will not always be her resting-place; for the favour of geographical position is as fickle as the caprice of man. That which happens, as in a moment, in the life of man, happens also in the life of our planet after myriads and myriads of years, but it happens none the less certainly for its long delay. There are, however, more urgent problems to interest our short-lived race than those which concern the future retreat of civilisation from Europe; at the same time it is only fitting that science, while pointing out what is, and what has been, should also show what will be in the long future.

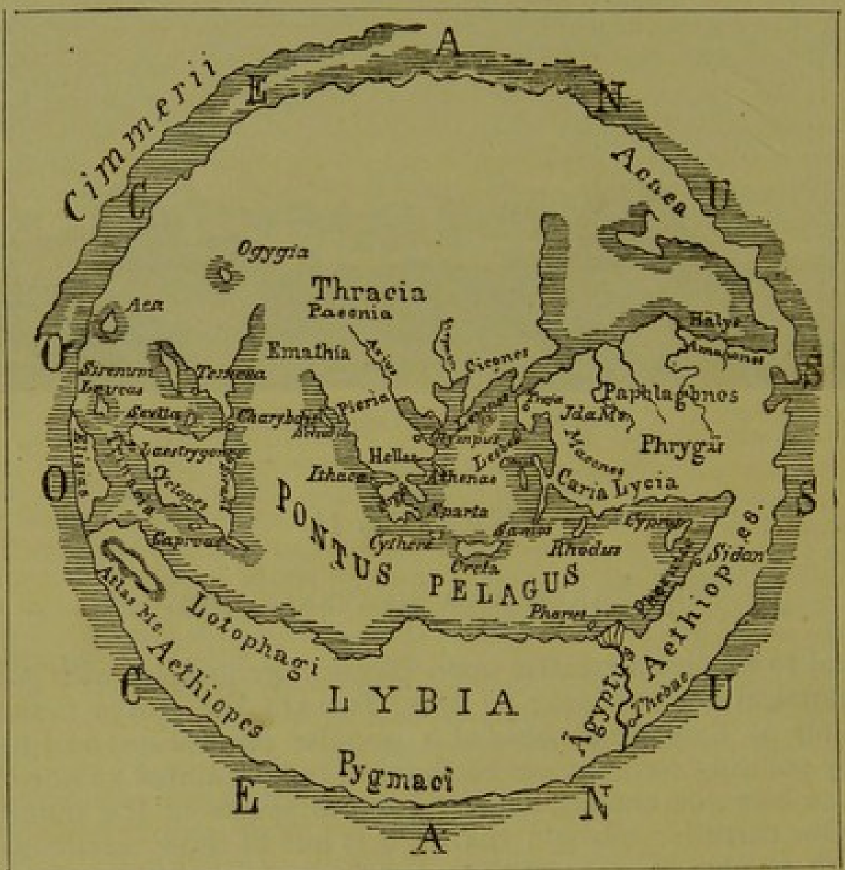
THE EARTH AS SEEN FROM THE MOON.

CHAPTER II.

THE EARTH AS A HEAVENLY BODY.

IT is usual to preface a treatise upon physical geography with a few purely astronomical observations; to bring forward the truths taught by that science, so far as they are capable of a popular exposition; and to begin, for instance, by pointing out that our earth is not to be counted as one of the stars, or nebulæ, or suns, or comets, with which the spaces of the infinite universe abound. Our earth is a planet; that is, it is one of those numerous heavenly bodies which revolve in a nearly circular course round the sun, and receive from it their light and heat. Without dwelling on those particulars which belong to astronomy as such, we must cast a hasty glance on the cosmical position of our planet, if but to learn how small and insignificant is the part which not only the earth, but the sun itself, plays in the great organism of the universe. If, then, we launch ourselves into the depths of this star-filled infinite space, we find on all sides stars and groups of stars, and nowhere any sign of an end of material creation.

Certain tracts of the heavens are absolutely unsearchable, even with the aid of the most powerful telescope. Whether somewhere in the universe a last star shines over the yawning gulf of physical nothingness can never with our present optical resources be learnt; for the very ray of light which guides us would fail, baffled and paralysed, unable to penetrate the space before it. The most distant stars of which we are cognizant shine upon us with mild radiance from the faint gleaming track which crosses the heavens, and which we call the Milky Way. For a long time the elder Herschel imagined that he had penetrated, by means of his telescope, to the outer boundaries of this region, but he was soon convinced of the unfathomableness of the starry ocean, whose bottomless abyss no plummet has sounded. It is therefore wholly unscientific to speak as, for instance, Proctor has done of its boundaries, and to attempt geometrical representations of its form. According to his opinion, the milky way is formed like the small "g" of our written alphabet; but this statement is purely imaginary, and cannot be accepted as a correct description. A scientific method of investigation leads us to a very different conclusion. It teaches us that the apparent circular shape of the milky way is nothing but an optical delusion, produced by the position of an



THE WORLD AS KNOWN IN THE TIMES OF HESIOD (p. 12).

indefinite number of nebulæ and clusters of stars scattered over one and the same plane. This plane appears to us as the tract of the milky way.

The stars which shine by night above our heads, and countless other stars which we are able to see through a telescope, belong to a nearly spherical group of stars within which the sun and our earth have their appointed place. Between the stars which make up this group we catch glimpses of myriads of other groups seen in perspective, as if arranged in a great circle, while in reality they are all scattered over the same plane.

All these systems, to which our own solar system belongs, are not placed exactly upon one level surface; on the contrary, they afford here and there glimpses of remote depths, beyond and through which we see the sections of the milky way. There do not exist, as was formerly supposed, milky ways separate one from another, but only one united tract; and from whatever group of stars we looked out upon the universe we should gaze upon this same milky way.

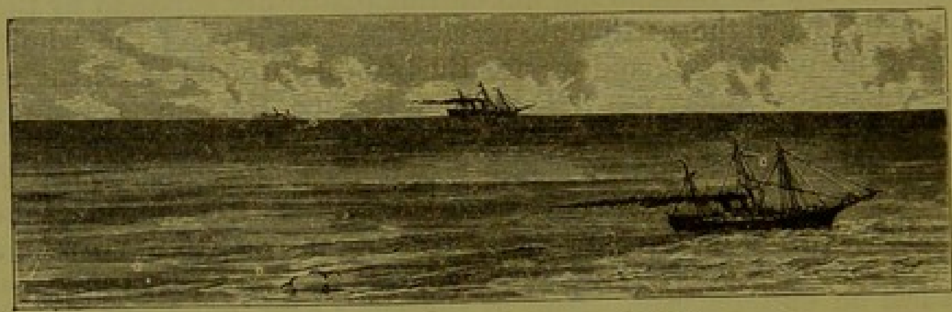
It is easy then to admit, from what has been advanced, that the starry strata of this wonderful region are indeed unfathomable by human effort. The separate stars of our own system are unequal both in brilliancy and in distance from us and from each other. The nearest star of which we are cognizant is Alpha, in the constellation of the Centaur, and its distance amounts to $20\frac{1}{4}$ million miles. The beautiful dog-star, Sirius, is 90 billions of miles distant from us; and as the sun, if it changed places with Sirius, would only give out $\frac{1}{30}$ of the light afforded by the latter, it is evident that the sun has less light power in just that proportion. Whether this difference in brilliancy depends, as some assert, on the difference of age existing between the two heavenly bodies, cannot be proved, for nothing is known as to the relative ages of the stars. It is however certain that as there was a time when the stars did not shine, so the time is coming in which their light will cease, and their heat fail.

As mechanical force is generated by heat, so, conversely, the amount of heat can be expressed by the mechanical force exerted. If then we investigate the mechanical force which the sun sends out in the shape of heat, we find that in every minute 1,026 billions horse power reaches the earth in the sun's rays, and that all life and motion on this planet are supplied by the force so expended. Now the earth only receives $\frac{1}{2,340,000,000}$ part of the whole light power sent out by the sun, and we are thus enabled to calculate the amount of light and heat actually expended. Unless, then, the sun is a miraculous body created out of nothing, and supported by a perpetual exertion of independent power, we must conclude either that its daily expenditure of light and heat is made good in some way or other, or that it cannot last for ever. There is, however, no known source which could provide the sun with a continual fresh supply of light power, and therefore we know that the star of day must at last be extinguished. And as the sun's heat must one day die out in space, so also will the planets find an end of their existence, and precipitate themselves upon the sun, because in their movement they encounter a certain resistance from the material which pervades all space. This resistance is, it is true, so slight, that myriads of years must elapse before the catastrophe can actually come to pass. Our earth, too, must end as she began, in liquid fire, and if her destruction is witnessed by the inhabitants of some neighbouring planet, it will appear to them like the sudden rising of a new sun. Similar phenomena have often been seen from our earth, and we are at liberty to conjecture what is taking place upon the exploding planet.

Whether this crash and fall of the planets on the sun will be followed by the creation of another planetary system is a question generally answered in the affirmative, but whether in process of time there will not come a final cessation of this creative force is a thought before which we can for the present afford to suspend our enquiries. Suns may and will crush down on suns, stars and clusters of stars may be dispersed in nebulous masses, and rise to fresh existence, and it is probable that this process may go on without interruption; for the universe is, it has been well said, a reversible machine. But paltry as may seem the part played by the human race in presence of this overwhelming aggregate of lifeless matter and dead force, it is yet the decisive and the highest part; for the whole universe, with all its suns and stars, sinks into nothingness before the extinction of the last consciousness of a sentient being.

Shape of the Earth.

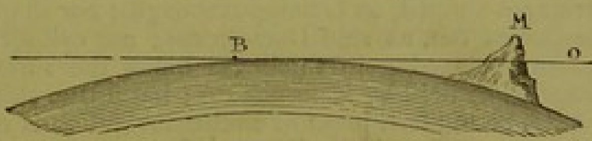
It is now so universally acknowledged that the earth is spherical, that it is difficult to form a true conception of the time and trouble which were necessary to establish this elementary axiom as an accepted truth of geography. The Greeks of Hesiod's day, following the deceptive evidence of their senses, looked upon our planet as a flat disc surrounded by the ocean. Its diameter, according to their view, was inconsiderable; for its eastern boundary lay by the river Phasis in the Caucasus, and its western a few days' journey beyond Sicily (Trinakria); later on, this boundary line was removed to the Pillars of Hercules, the present Straits of Gibraltar. The centre was occupied by Hellas and the cloud-capped summit of Mount Olympus. As to what lay beyond Phasis and the Pillars of Hercules, or as to the extent and boundaries of the outer ocean, their ideas were of the vaguest. Weird fables were current of an awful waste of water; a sea of darkness, thick with slime, and brooded over by dense masses of vapours, which repelled every attempt to penetrate its fearful mysteries. But even in Plato's day grander conceptions of the earth's size prevailed. He writes: "We who live between the Phasis and the Pillars of Hercules look only upon a small portion of the earth, where we have settled round the shores of the



A Ship Disappearing below the Horizon.

inland sea like ants or frogs round a marsh." Plato, moreover, believed the earth to be shaped like a die, and that for the sole reason that he considered the cube to be the most perfect form. Aristotle, however, and the later Greeks were perfectly well aware of the spherical form of the earth. Later on the true belief was lost again, and we find the professors of the University of Salamanca combatting Columbus' assertion of the true form of the earth with texts from the Psalms and quotations from the Fathers of the Church. Now-a-days there are no lack of proofs of the earth's rotundity. Perhaps the most popular is that afforded by the disappearance of a ship below the horizon, and its reappearance above the line which apparently parts sea and sky. Almost all the popular proofs were known to the Greeks; one only, and that beyond all others conclusive, namely, the circumnavigation of the globe, was reserved for comparatively modern times to witness.

Among the proofs of the earth's true shape is the fact that, the higher any one is placed above its surface, the more extended is his circle of vision. If the earth were a flat disc, we should, apart from the inequalities of surface and the more or less transparent state of the atmosphere, see as far from a height of 10 feet as of 100 or 1,000 feet. But as a matter of fact this is not the case. At the height of 10 feet we overlook a circle of 8 miles in diameter; at the height of 100 feet the circle of vision has a diameter of 25 miles; at the height of 1,000 the diameter extends to 80 miles. From the summit of the Brocken, where the gallery of the Brocken Tower stands 3,775 feet above the level of the sea, we overlook a circle of 146 miles. From this gallery can be seen in good weather the Weser Mountain range and the neighbourhood of Leipsic, points the distances of which correspond very closely with the calculations above given. One of the high peaks of the central Tyrolese Alps is called the Great Venetian, from a legend that some shepherds who were seeking their sheep saw from its summit the Adriatic Gulf. Now the Queen of the Adriatic lies in a direct line 112 miles from the above-named peak, and, according to the investigations of F. Nicolai, the formation chain presents no obstacle to the line of vision. No one has as yet, however, succeeded in gaining a view of the gulf from the Great Venetian, and even the famous mountaineer and Arctic explorer Payer failed in the attempt. These failures must of course be ascribed to the unfavourable conditions of the atmosphere, for the circle of vision from the mountain summit embraces a view of 260 miles. The panorama of the Great Venetian stretches westward to the Rhine and the Lake of Constance; northwards to Regenburg and Straubing; eastwards over the Duchy of Carinthia; and southward almost to the mouth of the Po. The mountain Mongo in Spain is 2,286 feet high, but it can be seen at sea at a distance of 23 miles, on the horizon, looking like a little island, the base being hidden by the curve of the sea. The accompanying figure shews this more in detail. The spectator in B looks horizontally across the sea in the direction B O. This line B O only meets a small part of the mountain M, of which the foot is hidden by the curved line of the sea.



The surface of the earth is not flat, but subject to numerous inequalities of mountain and valley. These inequalities, however they may influence the mathematical rotundity of the earth, are utterly insignificant when looked upon in comparison with the size of the globe. No one would dispute the spherical form of a cricket ball because a few grains of sand adhered to its surface; and in comparison to the earth's diameter the highest mountain is scarcely so large as a grain of sand. If we imagine a terrestrial globe 16 feet in diameter—that is, of a size such as has probably never been manufactured—the highest mountain would, in comparison to the diameter of the globe, be represented by the height of about $\frac{1}{12}$ of an inch. It is not then the presence of mountains which militates against the earth's convexity; the deviation from the true spherical form is caused by the slight flattening of the poles, which has made our planet a spheroid rather than a true sphere. This flattening does not amount to more that $\frac{1}{289}$ of the greatest diameter; that is to say, the polar diameter is shorter by the above fraction than the equatorial diameter. It is not often that this divergence has to be taken into account; and it would be utterly impossible to make it perceptible to the spectator on any terrestrial globe.

Copernicus, in his work *De Revolutionibus Orbem*, recapitulates all the proofs of the earth's true form with which he was acquainted. He says: "It is self-evident that the earth is round, because she rests everywhere upon her central point. Although, owing to the presence of mountains and valleys, the eye does not at once grasp the idea of a perfect sphere, yet these inequalities do not really affect the real convexity of the earth, as can be shewn by the following observations: The traveller journeying towards the north sees one part of the heavens rise in proportion to his advance, while the other half sinks in the same proportion ; the stars in the vicinity of the Great Bear seem to be always above the horizon, and some southern stars apparently never rise above it. Thus Canopus is not seen in Italy, and is clearly visible in Egypt ; while the Italians see the farthest star of Eridanus, which is hidden from our colder clime. On the other hand, the southward wanderer beholds those stars which we cannot see, and loses sight of those visible to us. Now this inclination of the heavens has always such a correspondence to the measurement of the earth's surface as could only be found in spherical figures, which proves that the earth is contained between the two poles, and that it is of spherical form. Moreover, the dwellers in eastern lands do not see those eclipses of the sun and moon which are visible in the west, and the inhabitants of the west do not see those visible in the east, while people living between the east and west see the eclipses at different times, which exactly correspond to their position on the sphere. And the sailor is able to testify that the water is subject to the same form as the land; for the shore, which he cannot see from the deck, he sees at once from the summit of the mast. And conversely, a light placed at the masthead appears to a spectator on the shore, who watches the ship sail away, as if it disappeared at length by sinking beneath the horizon. It is clear also that water, true to its liquid nature, strives downward, and never rises higher from the shore than its convexity allows. Therefore the land projects above the water just so much as it is accidentally higher, from which I hold it proved that both land and water strive to sink downward to a central resting-place, and that there is no other central point of the earth's circumference ; also that the separated parts of the land are filled up with water, and that therefore the proportion of water to land is small, although considerably more water appears on the surface. Again, it is evident that the land, with the water flowing round it, can have no other shape than that indicated by its shadow. Now the shadow cast by the earth upon the moon is no other than that which would be cast by the section of a perfect sphere. The earth therefore is neither flat, as Empedocles and Anaximines supposed; nor trumpet-shaped, as Leucippus thought; nor shaped like a basin, according to Heraklidus; nor hollowed out, as said Demokritus; nor cylindrical, as declared by Anaximander; nor a flat plain, decreasing in thickness below the surface, and sending out roots into the infinite depths, as held by Xenophanes ; but a true sphere, as taught by philosophers."

The modern proof of circumnavigation is neither difficult nor infrequent. Not long ago a wealthy English family started on a pleasure trip round the globe in their private yacht, with servants and children on board, and have given us the description of their voyage in an entertaining book. Only to compare their account with the story of the sufferings and perils of the earlier heroes who first dared the exploit is enough to shew the immense strides made in the subjugation of the elements to the will of man.

With this in view, let us give a brief *resumé* of the first voyage round the world, undertaken by Fernando de Magalhaen in 1519. This pioneer of science conceived the idea of sailing westward to the distant Moluccas, on the eastern coast of Asia. After the well-known difficulties and intrigues so familiar to the readers of the life of Columbus, Magalhaen succeeded in obtaining five ships from the Spanish Government. They were fitted out at Seville, on the Guadalquiver, and on the 20th of September, 1519, the little squadron put out to sea. Estebao Gomez, Sebastian el Cano, and other officers held subordinate positions under Magalhaen, who commanded in all 237 men. On the 13th of December the Gulf of Rio de Janeiro was reached, and a brisk trade carried on by barter with the inhabitants of the country. Two weeks later, on the River Plate, the explorers fell in with cannibals. One of these savages, with the frame of a giant and the voice of a bull, approached the ship, but ran away when a hundred men prepared to land and trade with the natives.

Magalhaen resolved to winter farther south, in the Bay of St. Julian. At first the Spaniards were all alone, but after two months had passed they saw a giant whose waist they could scarcely reach. Soon others of equal stature appeared, and a trading intercourse was at once set on foot—an intercourse not always friendly, since one of the sailors, we hear, died from the wound inflicted by a poisoned arrow. Some of these giants were taken prisoners, and proved to be enormous eaters, devouring every day a basketful of ship's biscuits, and drinking off half a bucketful of water at a draught. A mutiny arose among the Spaniards, which Magalhaen put down with terrible severity; and when discipline was restored, he sailed further along the Patagonian coast, and on the 21st of October, 1520, he discovered the entrance to the famous straits which lead to the Pacific Ocean. The straits were explored, but during their exploration Gomez deserted with his ship, and sailed back to Spain.

Magalhaen accomplished the passage of the straits, and on Wednesday the 28th of November, 1520, he launched the keel of his ship *Victoria* upon the watery waste of the great unknown ocean. Quickly the continent of America retreated from the gaze of the daring sailor, who had not the slightest idea of the extent of the ocean before him. For four months he sailed on and on across the endless sea ; provisions began to fail, and the navigators were in sore need of water. "The biscuit which we ate," says Pigafetta, who describes the journey, "was no longer anything like bread; it had an intolerable stench, and was full of worms, which had eaten up the substance of the biscuit. In order not to die of hunger, we were forced to eat the leather which we had placed round the mainyard, to prevent the wood from being worn by the rope. These pieces of leather, from having been so long exposed to sun and wind and water, were so tough that we were obliged to let them soak for five days in sea water, to make them a little tenderer, and then we toasted them over the coals, and ate them. More than once we were driven to eat shavings of wood, and mice were looked upon as such dainty fare, that we paid for them at the rate of half a ducat a-piece."

Unfortunately the sailors missed the fertile land of Otaheite, and only fell in with "two miserable islands" to the north of the latter place, so that they found no relief until they reached the Ladrone Islands. Full of wonder, they describe the marvels of the country and the manners of the strange island folk, who, as it seems, had never set eyes on foreigners before. Magalhaen at last found a healthy resting-place in the Philippine Islands, and entered into alliance with the king or rajah of a neighbouring island. This man, who was to a certain degree civilised, consented with his subjects to receive baptism; he also managed to entangle his visitors in a quarrel with the prince of an adjoining country. Magalhaen, with forty-five armed men, attacked 1,500 of the enemy. The affair came to a hand-to-hand encounter, in which the Spaniards were forced to retreat. Their leader fell wounded to the ground; once and again his men saw him struggle to rise and turn towards them to see if they could help him, and then he sank back, and rose no more.

So died Fernando Magalhaen (27th April, 1521), one of the greatest and bravest men of all time, and the first who ever sailed round the world. For he did practically sail round it, since the way back from the Philippine Islands was already well known.

Several of Fernando's companions perished by the treachery of the king of Zebu; the rest escaped to an adjoining island, and sailed for Borneo, where they met with a magnificent reception from a Mohammedan king.

But here also treachery lurked; the two remaining ships of the squadron were attacked by a numerous fleet, which, however, was successfully evaded by the Spaniards. Sailing onward, the adventurers fell in with the governor of Palawan, whom they took prisoner, in order to extort provisions and stores. With the same object they captured a ship near Mindanao, on board which was the brother of the king of that island.

On the 26th of October, a fearful storm, evidently a cyclone, broke over the ships, and brought them into great danger. "We prayed to God," says Pigafetta, "that He would save us, and immediately we saw upon the masts our three saints, who lighted up the darkness for us—St. Elmo on the mainmast, St. Nicholas on the foremast, and Santa Clara on the mizen-mast, where they rested plain to be seen for two hours. For this great mercy vouchsafed to us we brought them each an offering, and promised them each a slave." At last, on the 6th of November, they sighted the Moluccas. "Then we thanked our gracious God, and fired off a salvo of artillery; and no one will grudge us our great joy at sight of these islands, who reflects that merely for their sake we had wandered over the sea for twenty-seven months all but two days, and had visited a multitude of islands."

For seven weeks the Spaniards stayed in the Moluccas, taking in a stock of spices and provisions, and then sailed for Timor. On this voyage they lost another ship, and only the admiral's ship, the *Victoria*, remained to traverse the Indian Ocean under the command of Sebastien el Cano. The Spaniards would fain have put into Mozambique, for their stores were running dreadfully low; but it was better to die of hunger than fall into the hands of the Portuguese. So on the 6th of May they sailed round the Cape of Good Hope, and steered northward for two months, during which time twenty-one men of the crew died.

At last their provisions were absolutely at an end, and only just in time the *Victoria* reached the islands of Cape Verde, and cast anchor before Santiago, after an uninterrupted voyage of five months. Even here it was necessary to have recourse to stratagem, for the islands were, and still are, a Portuguese colony. The men who were sent out in the boats to fetch provisions from the land had orders to make as if they were come, after great hardships, from America, and not from the Cape of Good Hope, and as if Magalhaen, with his two other ships, had gone back to Spain. And in this way they succeeded in exchanging some of their goods for two boatloads of rice. But great was the astonishment of the Spaniards to find that on land it was Thursday, while the ship's log stood at Wednesday: a whole day had thus been lost in their long voyage from east to west, and surely never was day so gloriously lost.

When the sloop approached the shore for the third time to take in provisions, the sailors on board the *Victoria* saw that she was detained. One of the men had betrayed the secret that Magalhaen was dead, and that the *Victoria* was the sole remaining ship of his squadron, and already the Portuguese were making ready to attack and board her, when she quickly took to flight, and so saved the expedition.

On Saturday, the 6th of September, they sailed into the Bay of St. Lucia; and on

Monday, the 8th, amid the thundered salvos of artillery from the Molo, they cast anchor for the last time before Seville. But of the sixty men who had sailed homewards from the Moluccas only eighteen remained, and these were most of them in a pitiable condition. Of the others, some had deserted at Timor, others had been put to death for various crimes, and others had died of hunger on the voyage. On the following day the survivors, barefooted and stripped to their shirts, walked in procession, carrying wax tapers in their hands, to the church of Santa Maria of Antigua, as they had vowed to do in the time of their sore distress.

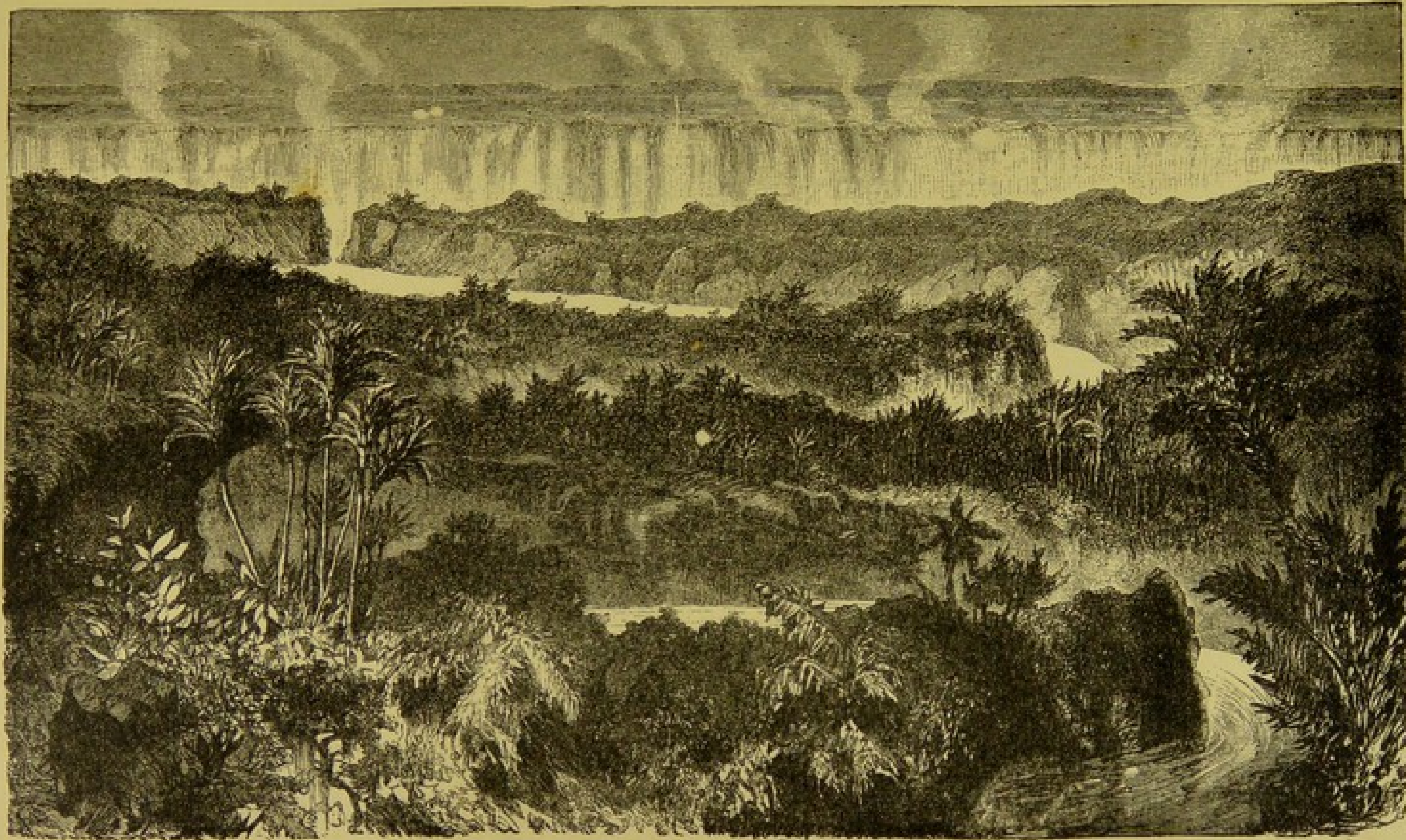
The world had been sailed round for the first time! Fifty-six years passed away before the adventure was repeated. This time it was an Englishman, Francis Drake, who sailed round the world in the years 1577—1580; six years later he was followed by another Englishman, Thomas Candish; then some Dutchmen accomplished the exploit; and in 1614—1617 a German, George Spillery, sailing however in a Dutch ship. Now-a-days the voyage is by no means unusual; and it is no unfrequent occurrence to hear a man say casually in the course of conversation that he has sailed round the world.

The fact that our earth is of spherical form gives a valuable hint as to the history of its creation, since it is at once suggested that it must have been at one time in a fluid state. Such a mass, left to itself, would of necessity assume a spherical form; and if a rotatory motion set in, the liquid mass would equally of necessity be flattened at the poles, and so become a spheroid. This has actually been the case with our earth; and thus, as has been rightly said, the shape of the earth reveals its history.

The question whether the original fluid condition of the earth consisted of watery or fiery matter has been answered in favour of the latter supposition. Apart from many other reasons which will be mentioned later, it is sufficient to notice here that there could not have been sufficient water available; and that, if there had been, water does not possess sufficient solvent power to liquefy the various component parts of the earth. Fire alone is equal to such a task; and therefore the primeval condition of this globe must have been one of liquid fire. Only by slow degrees was the earth's surface hardened into a solid crust, which ages afterward became the scene of organic life. The thickness of this crust at the present moment cannot be determined. While some maintain that the interior of the earth has long ago been thoroughly coated and hardened, others believe that the greater part of the globe is still in a state of fiery fusion, surrounded only by a crust varying in depth from twenty-three to forty-five miles. This latter hypothesis is supported by the increasing temperature of the earth as we descend below its surface; but we have only been able so far to penetrate to a depth of 3,280 feet at the most, and this is so little in comparison with the earth's diameter, that science hesitates to pronounce upon such evidence any conclusion as to the state of the earth's core and centre.

SIZE OF THE EARTH.

The question of the earth's size is intimately connected with that of its shape. As long as the earth was looked upon as a flat disc, with roots descending into infinite space, the ideas concerning its size were necessarily of the vaguest. Not until definite and scientific views began to obtain, and the spherical form was acknowledged as the true one, was the question asked, What is the size of this sphere? It was Eratosthenes, the philosopher in charge of the world-famed library in Alexandria, who first conceived the idea, stupendous indeed for the age in which he lived, of ascertaining the extent of the earth's circumference by direct measurement. He had heard that on a certain day the sun lighted up the surface of some water lying at the bottom of some very deep wells at Syene, in Egypt. Very properly he concluded that the sun must be on that day exactly vertical above these wells, as is actually the case. At the same time he found that in Alexandria the sun is distant from the zenith by the fiftieth part of its apparent course; and from these data he estimated the distance between Syene and Alexandria at 5000 stadia. Eratosthenes then said to himself, that if the curve of the heavens between these two cities was $\frac{1}{50}$ of their circumference, then, since they are situated upon a spherical globe, the distance would also be the fiftieth part of the earth's circumference, which, according to that calculation would amount to $50 \times 5000 = 250{,}000$ stadia, reckoning the stadium to be, as is most probable, equal to $\frac{1}{10}$ of a geographical mile.



VICTORIA FALLS, ON THE ZAMBESI, SOUTH AFRICA.

About one hundred years after Eratosthenes died, a Greek philosopher attempted another calculation of the earth's circumference. He found that the curve between Rhodes and Alexandria was $\frac{1}{48}$ of the circumference, and estimating the distance between the two places to be 5000 stadia, it followed that the circumference was 48 × 5000 = 240,000 stadia, or 24,000 geographical miles. This measurement was commonly accepted as correct, and not until the second half of the seventeenth century was a trustworthy statement obtained. Already, in the ninth century of our computation, the Caliph Al-Mamum interested himself so deeply in this subject that he sent the two philosophers, Chalid the Abdolmalik, and Ali ben Isa, to measure by rod and line the distance between two given points. The distance was reported to be 450,600 ells, and that consequently the two places were two degrees apart, and the whole circumference of the earth was given as 180 × 450,000 = 81,108,000 ells. This calculation was most likely nearly right, but we are not able to base any conclusions upon it, because the length of the Arabian ell is uncertain. The Arabian writers tell us, indeed, that their ell contains twenty-seven inches, and that each inch contains six barley-corns, but no one has thought fit to give us any imformation as to the length of the barley-corn.

It is easily seen that, taking the earth form as spherical, it will be easier to calculate its size in proportion as we are able accurately to determine the distance of the curve of the sky between two points, and also to express the shortest part of this distance in a definite measure. Antiquity and the middle ages were but poorly furnished with aids for such measurement; there was a total lack of accurate instruments for the purpose, and the eye of man unaided by the telescope and the microscope can by no means lay claim to sufficient accuracy or power. It was reserved, then, for modern science to determine finally the size of our planet in a satisfactory manner. In 1664, the more accurate measurements began under the direction of Picard, who set on foot the so-called measurement by degrees. He reckoned the degree as 124,805 yards, which gave the circumference as 44,408,840 yards.

A scientific expedition was sent out by order of the French Government, first to Peru, and in the following year to Lapland. The mission of each expedition was to measure a certain section of the earth's surface, and to draw conclusions as to its size. It was found that at the equator a degree measured 121,073 yards, and at the arctic circle 123,532 yards, so that in the north a greater distance must be traversed to go over the same curve of the circle; in other words, the earth is flatter in the north than in the centre. This fact, which has been confirmed by all subsequent measurements, had been stated long before by the immortal Newton; indeed, the French expeditions were fitted out to test the truth of Newton's theory.

It is not necessary to name specially all the great investigations which have been undertaken during the last hundred years by French, English, German, and Russian scientific men to learn the size and shape of the earth. Enough to indicate briefly the results. According to the most recent statements, the length of the half-diameter at the equator is 3,962·5 miles, and at the poles 3,949 miles, or 13½ miles shorter than the former. The flattening therefore amounts to nearly $\frac{1}{289}$ of the whole. The circumference at the equator measures 24,856 miles; the length of a geographical mile is 2,024 yards.

The surface of the earth contains 197,000,000 square miles, and its mass, or volume, 260,000,000,000 cubic miles. The meridians, owing to the flattening of the poles, are not circles, but ellipses; indeed, recent researches make it probable that the equator itself is not an exact circle; and if that is so, the earth, instead of having only two axes, must have three, a polar axis and two equatorial axes. The districts near the Gulf of Guinea and western Polynesia are the farthest from the earth's centre, and the slightest convexity of the equator is found near Ceylon and the peninsula of Panama. The difference in question, however, is only a matter of 1000 feet, which shews us how accurately the measurement has been carried out, since the variation in such a vast extent is much less than the length of many familiar streets in our great towns.

It is not only of scientific interest to arrive at an accurate knowledge of the earth's size, it is also of practical importance; indeed, it was the latter ground which gave such an impulse to the various expeditions we have just mentioned. The object sought was the discovery of some standard measure, which, from its special nature, should be willingly accepted by all civilized nations, and easily recovered, if by mischance it should ever be lost. We who live in times when this measure is so generally accepted can scarcely form an idea of the state of things which existed when, as at the end of the preceding century, almost every one of the nearly three hundred independent petty masters of the German Empire had his own standard of weight and measure, to which he clung the more obstinately in proportion as it differed most from that of his next-door neighbour. Italy alone had more than two hundred measurements of feet, and even in Paris such a chaotic state of things prevailed that in 1789 the larger towns petitioned for the introduction of a standard system of measurement. The French Academy, which was to pronounce upon the point, recommended as its standard of unity the ten millionth part of the distance of any point of the equator from one of the poles, or the so-called meridian quadrant. The exact length of one of these quadrants was to be decided by measuring the distance between Dunkirk and Barcelona. This proposal was accepted by the French Assembly on the 13th of March, 1791, and in the following year the measurement was begun. This measure was to receive the name of *metre*, and the distance from the equator to the pole along the meridian was to be called at once 10,000,000 metres. In this metric system, the length of the metre is equal to 443,296 Prussian lines, or one yard four and a half inches, and on the 10th of December, 1799, this was accepted as the statute measure.

Many most accurate normal measurements were recorded in the archives of the French Republic, with the design of having recourse to them for certain special purposes. For ordinary use an accredited copy was engraved and deposited in the Observatory at Paris. The metre is steadily winning its way among civilized nations, and yet the original idea of discovering a natural measurement has not been attained. Different measurements of the distance from the equator to the pole gave different lengths for the metre, according as it was divided into 10,000,000 metres, or the metre was reckoned at 443,296 lines. This disagreement is a necessity of the very act of measurement itself, which can never lay claim to absolute perfection of accuracy; and secondly, it is a necessary result of the uncertainty of the meridian divisions of the earth.

It is, of course, impossible actually to measure the earth's surface from the equator to the pole, and therefore the length of each meridian quadrant can only be determined by a supposition as to the length of the whole. Now the most careful and successful measurements establish results which convince us that the earth does not represent the figure of a spheroid produced by the turning of an ellipse round its lesser axis, but that in some places its convexity is greater and in others less than is compatible with the idea of a perfect spheroid. The measurements carried on lately in East Prussia lead to the conclusion that the true shape of the earth bears the same proportion to a spheroid as the surface of troubled water bears to that of the same water at rest; the inequalities being very slight, perhaps a matter of a few miles. If, therefore, the idea of an absolute natural linear measurement is inadmissible, yet the metre still remains the greatest boon and advantage offered by the decimal system of notation, and with the latter must sooner or later be the accepted standard of the civilized world.

The Earth's Rotation round its Axis.

The commonest delusion to which men's sense of vision has exposed them is the idea that the heavens revolve round our earth. Ever since a thinking human being has looked upon the objects above and around him, he has seen sun and stars appearing to rise in the east, and set in the west, while the earth remained stationary beneath his feet. In all times and places this deceptive phenomenon has been perceived, and yet it is nothing but a mere illusion of the senses. For the heavens do not move round the earth, and the earth does move perpetually round her own axis. No one contests this truth at the present day, but it is interesting to remember that no absolute proofs of the fact were forthcoming until they were no longer needed.

Let us see on what grounds Copernicus based his belief in the earth's rotation; he has brought them forward in the eighth chapter of his immortal work, after having first told us why the ancient sages thought that the earth rested quiet in the centre of the universe. Copernicus first says, that it is unreasonable to believe that the objects on the surface of the earth would fly off into space if the earth turned round its axis, because the heavens revolved, as his opponents admitted, and yet the stars, etc., remained in their places, although the movement of the whole universe must be so immeasurably quicker. "Why," he continues, "should we hesitate to admit that the earth has a movement corresponding to its shape, instead of saying that the whole universe, about whose bounds we are ignorant, is in perpetual motion? And why cannot we own that the movement apparently seen in the heavens is illusory, and the unseen motion of the earth is a reality? that the appearance is just what Virgil meant when he makes Æneas say, 'We set sail from the harbour, and the cities and countries retreat from our gaze'? For when a ship is quietly sailing on her course, and the sailor sees the places on the coast apparently moving alongside the ship, he knows all the while that they are at rest, and that it is he and his ship who move; and so it is doubtless with the apparent movement of the heavens. And what are we to say of the clouds and all that ascends and descends or floats within the air, except that not only the earth and the seas which are part of our planet, but also the air and every substance connected with the earth, are sharers in its motion; whether it be that the atmosphere being mixed with earthy and watery matter is of the same nature as the earth, or that by means of its close contact with the earth the same movement has been imparted to it?"

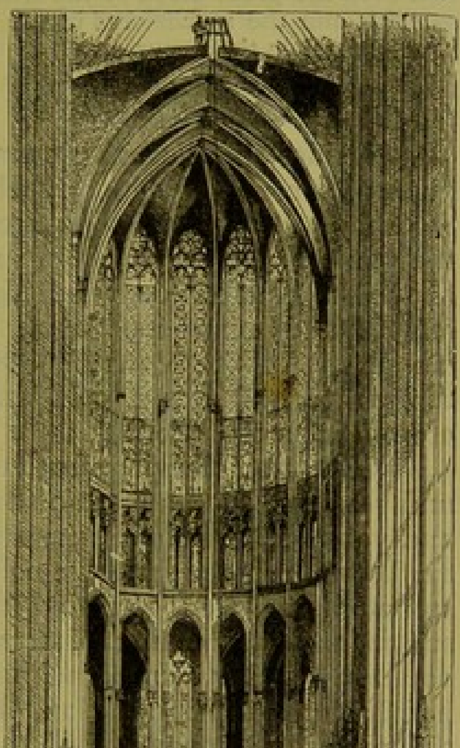
This was all that Copernicus had to say in support of his theory of the earth's rotation round its axis; and we must confess that although the probabilities were greatly in favour of his arguments, one or two incontrovertible and palpable proofs would not have been amiss. These proofs, however, were not so easy to find, since no one could set foot outside the earth, and therefore no one could escape taking part in its diurnal movement. Newton was the first to conceive the possibility of demonstrating the earth's rotation by an experiment. If, he reflected, the earth revolves, everything upon its surface must revolve the more quickly in proportion as it is farther from that imaginary central line which we call its axis. This greatest distance is of course found in the places lying just on the equator, and they move at the rate of 1,514 feet a second. From the equator to the poles the rate of movement gradually lessens; for in 40° north or south latitude the speed is only 1,094 feet; at 50°, 973; at 60°, 757; and at the poles, which represent the ends of the axis, it is null. Newton therefore pointed out that any object raised above the surface of the earth must move much more quickly than those which rest on the ground; for instance, the top of a church steeple would move faster than the foundations. Everything therefore in the world has its own natural speed of rotation, according to its distance from the surface of the earth. If then a stone is thrown from the top of a church tower, it will touch the ground rather to the east of the spot exactly under which it began to fall, because it preserves its quicker motion eastwards all the time it is falling.

The next thing was to test this theory by experiment, and Benzenberg devoted himself specially to the task at the beginning of the present century. He had an apparatus erected in the tower of St. Michael's Church in Hamburg, for dropping leaden balls, and he proved that they did actually fall eastward of the point from which they started. Later on he made a similar experiment down a coal mine in Schlebusch, with a drop of 260 feet, and the eastward divergence was shewn unmistakably. The divergence, it is true, is very slight, and can only be perceived when the experiment is conducted with great care, and at a considerable height.

Léon Foucault, however, pointed out a method by which the earth's rotation could actually be brought visibly before the eyes of the spectator, and that on a truly imposing scale. This was effected by means of the pendulum, of which the plane of oscillation remains unchanged, unless it is subjected to some force from without. "I am supposing," says Foucault, "that the spectator is standing on one of the poles of the earth with a pendulum of the simplest make, consisting only, that is, of a heavy, homogeneous ball suspended by a pliant thread to an absolutely fixed point. I assume also that the point to which it is suspended is an exact prolongation of the earth's axis, and that the supports which uphold it are not subject to the daily rotation. If the pendulum so placed should swerve from its position of equilibrium, and without any lateral movement communicated from without, yield to the force of gravitation, its centre of gravity will always return to a vertical position, and its ascent on the opposite side from its first movement will, by means of the speed attained, be almost equal to the height from which it started. Now the curve of the pendulum's oscillation is easily ascertained, and it preserves an unchanged position in space. If then these oscillations are kept up for a sufficient length of time, the movement of the earth from west to east will gradually become visible by its contrast with the immobility of the pendulum's plane of oscillation, which seems to possess a corresponding movement with the apparent movement of the heavens. If the oscillations are kept up for twenty-four hours, the revolution round the point of suspension will be complete. These are the ideal conditions under which a visible demonstration of the earth's rotation becomes possible. But, as a matter of fact, the point of suspension has to be found within this revolving world, and cannot be withdrawn for taking part in her rotation.

It was at first feared that this movement shared by the thread and the supports of the pendulum would alter the direction of the plane of oscillation. Experiment, however, has demonstrated that the thread, if it is round and homogeneous, can turn round itself to the right or to the left, without materially affecting the plane of oscillation, so that the great test could be carried out successfully even below the pole of our globe.

Foucault went on to shew what influence the distance of any special place on the earth's surface from either of the poles would have upon the plane of oscillation of the pendulum. At the equator the apparent rotation of this plane is null, that is, no revolution takes place; at the poles the revolution is completed in twenty-four hours. To test these theories, Foucault had a strong piece of cast-iron inserted in the ceiling of a vault, as a support for the thread of the pendulum. The thread was passed through the centre of a horizontal plate of steel, and consisted of a steel wire $\frac{6}{250}$ to $\frac{11}{250}$ of an inch in diameter and $6\frac{1}{2}$ feet in length. At the end of it was a solid ball of polished brass, whose centre of gravity corresponded with its own central point. This ball weighed 11 lb., and had at the lower edge a pointed projection, which seemed to be the continuation of the steel wire. When the ball was quite still, and it was necessary to start it, a thread which had been tied round it was raised and fastened to a firm point in the wall a little above the ground, and after waiting till the ball was again perfectly quiet, the thread was burnt, the loops of thread round the ball fell to the ground, and the pendulum, with no other force than that imparted by the law of gravitation, set itself in motion, and began a series of oscillations, the plane of which was soon visibly altered. At the end of half an hour the divergence was so great as to be easily recognised by the spectators, but it was more interesting to watch it close at hand, and note its gradual and uninterrupted advance. For this purpose, a board, in the centre of which a pencil stood point uppermost, was placed underneath the centre of the curve described by the swing of the pendulum. In less than a minute the metal point of the latter grazed the pencil, which then remained immoveable, while the pendulum slowly moved towards the left of the spectator, and shewed that the deviation of the plane of oscillation occurs in corresponding direction to the apparent movement of the heavens. The divergence itself corresponds exactly to the requirements of the theory; for while at the pole the plane of oscillation moves fifteen degrees in an hour, it moves at Munich only 11·31, so that at the latter place the pendulum must vibrate for 31 hours, and 50 minutes to complete its circle of revolution; and at Cayenne the hourly rotation is only 1·31.



Garthe's Pendulum Experiments in Cologne Cathedral.

Foucault has since repeated this experiment on a larger scale in the meridian hall of the Observatory at Paris, with a pendulum twelve yards long, which shewed the divergence after the second oscillation; and more recently Garthe in the Cathedral of Cologne, and Schwerdt in the Cathedral of Speyer, have conducted similar experiments on a magnificent scale, and with the happiest results. To render the divergence as clear as possible, a layer of fine sand was spread on the ground just under the point of the pendulum; the metal point traces its path along the sandy stratum, and every successive advance can be noted at once. It is not easy to describe the impression made on the spectator as he follows the slow majestic swing of a pendulum 132 feet long, such as Garthe has suspended in the Cathedral of Cologne, and by its steady advance perceive how he himself and the building in which he stands are moving uninterruptedly together with the whole world.

The rotation of the earth on its axis has continued practically unaltered: at the present time a day is, to ordinary observation, neither longer nor shorter than it was three thousand years ago. But still, the searching investigations of modern times have shewn that if absolute accuracy is insisted upon, the duration of the diurnal movement *has* undergone a slight change since the first days of astronomical observations. This slackening of speed has, within the last two thousand years, increased the duration of the day by the eighty-third part of a second! It is difficult to know whether to wonder more at the unchangeableness of the central force of rotation, or at the high development of science which has been able to take note of so small a discrepancy. It is also thought probable that slight irregularities of rotation, amounting to several seconds, have appeared within shorter spaces of time, and have righted themselves in longer periods. It is thus that certain anomalies in the movement of the moon indicate the possibility that since 1850 the rotation of the earth is in advance by two seconds of the ordinary movement. Inquiries of this nature are, however, in their infancy, and their solution remains for our posterity. It is nevertheless interesting to learn that even the great clock of the heavens, that is to say, the rotation of the earth and her satellite, and the movements of the starry vault above us, are suspected of shewing little irregularities in their course.

THE YEARLY REVOLUTION OF THE EARTH.

Besides the diurnal movement round her axis, the earth has also a yearly revolution round the sun, by which the unequal duration of day and night, and the change of the seasons, are effected. If the earth stood vertically upon the plane of the ecliptic, the sun would also from year to year stand vertically above the equator, day and night would always and everywhere be of equal length, and every spot upon the globe would have its own unchangeable climate. At the equator itself an intolerable heat would prevail, in the temperate latitudes a cold and cheerless spring, and in the polar regions eternal icy desolation.

Without enlarging further on this picture, enough is said to shew how unfavourable such a state of things would be to the development of our race, and yet there are some who would have us ascribe the present position of the earth, with reference to the ecliptic, as the result of an accident. As it is, the sun advances every year 23½ deg. north of the equator, and so occasions the summer of our northern latitudes; and then descends just as far below the equator, leaving winter behind him, and making summer for the southern hemisphere. The duration of day and night vary in correspondence with this apparent movement of the sun. When the sun stands vertically above the equator on the 21st of March, the day and night are equal everywhere, but at the north pole the day begins. On the 21st of June the sun has reached its greatest height with us, and it is midday at the pole. On the 21st of September the sun is again vertical over the equator, the days and nights are equal, and at the pole the night begins. On the 22nd of December the sun is at its greatest distance from the equator southward, our day is therefore shortest, and at the north pole it is midnight. From that day the sun begins to ascend once more, and on the 21st of March it is ready to run again its appointed course. In the southern hemisphere, of course, the above phenomena occur in reversed order; it is there midnight at the south pole, when it is midday at the north pole, and the longest day of the southern hemisphere is our shortest day.

The inequality between day and night increases from the equator towards the poles. At 20 deg. north or south latitude the longest day has 13½ hours; at 50 deg. 16 hours, and at 66 deg. 32 min. 24 hours. Tornea, in Finland, at the head of the Gulf of Bothnia, is just below this degree of latitude, and a spectator standing on the church tower of that town on the longest day can see the sun above the horizon at midnight. Still more imposing is the spectacle from the mountain of Avasatka, a little to the north of the town, on the left bank of the river Tornea-Elf. For many days the sun can be seen from this mountain without its sinking below the horizon. In the peninsula of Fiola the longest day lasts a month; in the Waigatz Island, two months; in Bear's Island, three months; in the south of Spitzbergen, four months; and in the north of Franz-Josef's land, nearly five months. The duration of the day is greatly influenced by the refraction of the sun's rays. We shall have to treat of this phenomenon later, and need only mention here that in consequence of it the sun often appears to be above the horizon when it is really below. Even in Tornea the sun does actually set for a short time, but it appears to rest with a reddish glow just above the horizon, and the appearance remains visible for days together. In 1694 there was a striking exhibition of this phenomenon, and King Charles the Eleventh of Sweden visited Tornea to see the midnight sun.

As we advance farther north, the refraction of the sun's rays becomes still more powerful; and some Dutch seamen who wintered at Nova Zembla in 1597, found that the sun was visible at midnight on the 24th of January, although, according to astronomical calculations, it should not have come into sight until the 10th of February.

We have said already that the summer half-year of the northern hemisphere lasts as long as the sun remains above the equator; that is, from the 21st of March till the 23rd of September, and is accordingly 187 hours longer than the winter half-year. As, therefore, the seasons are reversed in the southern hemisphere, it follows that there the winter half-year is 187 hours longer than the summer half-year. The reason of this unequal duration is that the sun takes longer to traverse that portion of its course which lies above the equator than that which lies beneath it. In this part the sun is nearer to the earth, and if the summer of the southern hemisphere is shorter than ours, yet the heat is more intense. On the whole, however, it has been proved that the amount of heat received by each hemisphere in the course of the year is equal. In saying this we speak only of the heat *received*, for it is by no means true of the heat derived from refraction. In the southern hemisphere the summer is hotter, but shorter by eight days, and the winter colder, and longer by the same time. These relations of climate between the two hemispheres are influenced, of course, by all the great laws of which we are speaking; and they are not permanent. For the northern hemisphere will not always have a longer summer than the southern, nor has it always had one; indeed, in consequence of certain astronomical conditions, the relative duration of the seasons in the two hemispheres will regularly be reversed, and this will happen in the course of periods of 21,000 years. In this sense we speak of climatic periods of this duration.

The Earth's Surface.

All that we know of the physical construction of our earth from direct observation is limited exclusively to its surface; for, as we have already stated, the greatest depths reached by our mines and shafts sink into nothingness in comparison with the earth's diameter, and the same may be said of the greatest ascents made by means of air balloons. So soon, therefore, as we turn away from the earth's position in the universe, and its various astronomical relationships, to contemplate and describe its own individuality, we find our knowledge strictly bounded by its surface. And we find also, that this surface presents us with a grand and vast field for exploration which has never yet been penetrated in all its recesses, but is continually revealing new treasures of subjects for enquiry and delight; it is in a special sense of the words—*our World.*

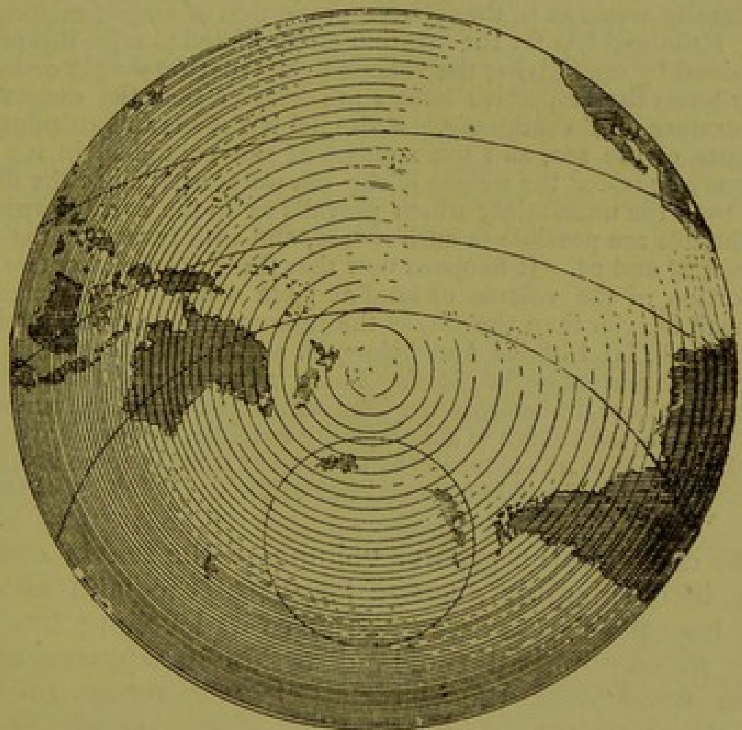
The scientific exploration of this world of ours is, however, of very recent date. What did we know three hundred years ago, in spite of Magalhaen's voyage of circumnavigation, of the interior of America and Asia? Nay, what did we know of the towns, rivers, and mountains of our own country? How things were in this respect two hundred and fifty years ago with the German people in "the Holy Roman Empire," we learn from Kepler. He was summoned to Linz, on the Danube, in 1612, to draw up a map of the district, and he set about the work with all his well-known zeal and assiduity. He began to question "churls and peasants, and inhabitants of every place;" for so, he tells us, "have all maps been made up to this present." Wherever he journeyed to look at a place for himself, he was forced to stay for a day until he fell in with some promising person whom he could beguile into the public-house and ply with questions of all kinds as to the locality. "Not one," writes Kepler, angrily, to the deputies, "would tell me anything for nothing, but every man answered me just so long as the drink lasted, or as he felt willing and disposed in his own mind." Moreover, poor Kepler had to struggle against the brutal ignorance and superstitious fears of the country people. He complains, "I have had many revilings and cruel offences done me by the rough, ignorant, and suspicious peasants, not only in markets and villages where I was wont to make my enquiries, but much more in fields and on the hill-sides, and in unfrequented paths, whither my researches led me; and I should doubtless have had more to withstand at the frontier places. From all which it may be seen that without the aid of a trusted post-boy or brave serving-man who had the art of writing, and without the company of some well-known farmer or notable bailiff, I could have accomplished nothing of profit." It is easy therefore to see that, strictly speaking, little more was known of the interior of Germany than of the interior of Persia or of Asia Minor.

Hemisphere of most Land.

The surface of our earth consists of land and water, and is surrounded on all sides by the air, or atmosphere. The proportion of land and water is, however, very unequal; for the surface of the sea is in comparison to that of the land nearly as twenty-seven to ten; that is, it is almost $2\frac{3}{4}$ times as great. And the distribution of the land over the surface is also very irregular. Most of the land is situated near together in the northern hemisphere, while the southern is principally oceanic. And the distribution would be still more unequal if, instead of taking the two poles as the centres of the earth's hemispheres, we divide the globe into two halves, of which London shall be one centre, and the Auckland islands the other. We should then regard these two divisions as the north-eastern and south-western hemispheres. The former is the land, and the latter the water hemisphere.

The illustrations will help to shew clearly how great the disproportion is, and we shall at once feel disposed to seek for some reason of the enormous inequality. It is, however, very difficult to account for this remarkable difference in the amount of land and water; and all the more so, because we know that the primeval configuration of our earth was entirely different from what it is at the present day. We can take into account the periodical floods and inroads of the sea, such as are known to have actually taken place; but even if the surface of the sea were to sink three hundred feet in the southern, and rise as much in the northern hemisphere, the preponderance of land in the latter would still exist. On the other hand, we must not over-estimate the disproportionate extent of land and sea. Humboldt was the first who attempted to give the cubic measure of the land. After him Peschel asserted that all the land upon the globe might be dropped into the Atlantic Ocean, and not fill it half full.

Leipoldt has recently introduced a new and more accurate estimate of the amount of land in Europe, based upon several systems of measure-



HEMISPHERE OF MOST WATER.

ment which were unknown in Humboldt's day. It was found that the average height of Europe above the level of the sea amounted to about 328 yards. Starting from this result, Krümmel has lately brought forward plausible estimates of the average heights of the remaining continents, and has found that the volume of all the land collectively, above the level of the sea, amounts, in round numbers, to 12,757,500 cubic miles. In order to compare this with the cubic measure of the sea, of which the surface measures 137,700,000 square miles, it is, of course, necessary to know the central depths of the ocean. We shall have to speak later on concerning this subject; for the present we may mention that Krümmel estimates the average depth of the sea at 3,684 yards, which would give the cubic measure as 285,950,250 cubic miles. So that while the surface of the land is to that of the sea as 1 to $2\frac{3}{4}$, the proportion of the volume of land and water is as 1 to 22. Twenty-two times the extent of the continents, therefore, as they lie scattered over the surface of the ocean, could be thrown into its depths.

But the land does not lie flat along the surface of the water; on the contrary, it descends below it, and rests upon mighty supports which rise like columns from the bottom of the sea. In comparing, therefore, the respective volumes of land and water, it is necessary to take these supports into our calculation. It is clear that the average height of these supports must equal the average depth of the sea; now the whole volume of the land below the surface of the sea amounts to 121,050,062 cubic miles, and is therefore in proportion to the volume of the sea as 1 to $2\frac{3}{5}$. This approaches very nearly to the respective proportions of the two surfaces; and if we consider that the calculations upon which these proportions are based can only claim to be approximately correct, we may still maintain that the proportion of the volume of sea and land is very nearly the same as that of their surface.

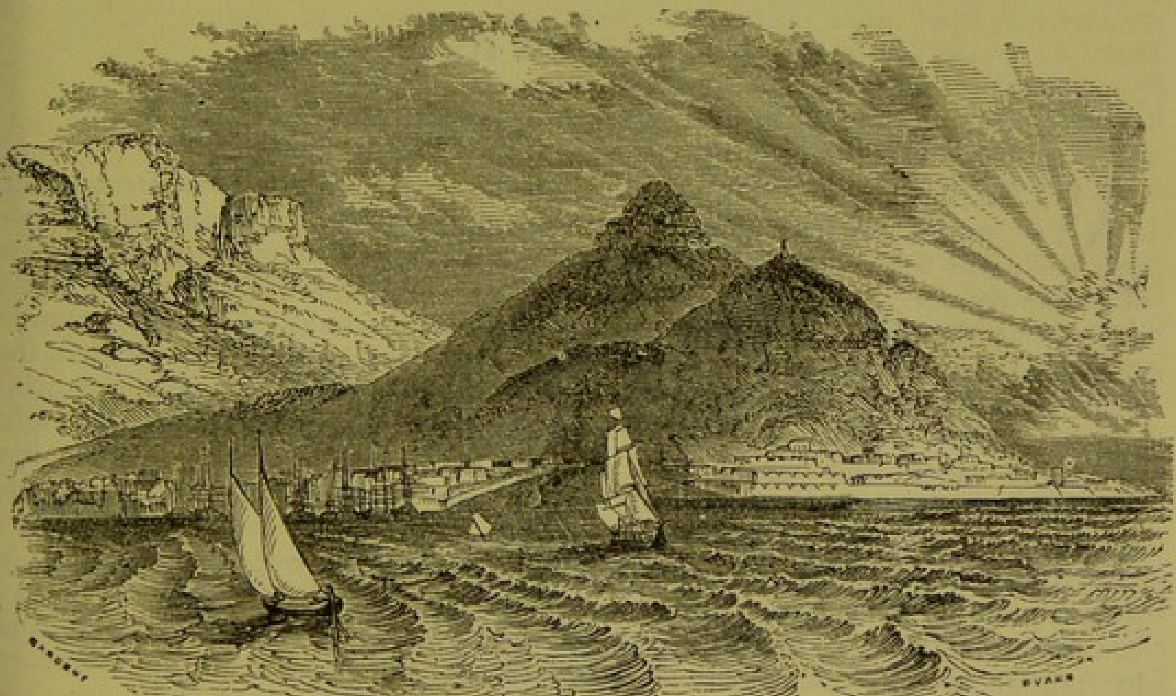
In the foregoing remarks we have been considering only the proportions of extent, and the question naturally arises as to the relative proportion of *weight* existing between the two great elements. Krümmel has for the first time endeavoured to solve this problem. The mass or weight is obtained by multiplying the volume by the specific weight or by the figures which shew how many times the respective bodies are heavier than the same volume of distilled water at a temperature of 4° centigrade. Krümmel has made this calculation with reference to the temperature of the sea, and the amount of salt contained in it; we may therefore with less ceremony consider the weight of the sea water as 1, since the difference from this estimate is less than the uncertainty which prevails as to the average specific weight of the land. Only estimates are possible in such a case, and with respect to the weight of the land they vary between $2\frac{3}{5}$ and $2\frac{3}{4}$. It happens now that these are the very two numbers between which the proportion of the volume of land and sea wavers. We conclude therefore that the land is as much heavier than the sea, as the sea exceeds the land in volume; or, in other words, if we reckon the land above and below the surface of the sea, its weight will be as great as that of all the waters of the globe. There is therefore, as Krümmel expresses himself, perfect equality of weight between the land above and below the surface of the sea.

Speculations as to the causes of this equality are idle, and we have at present no sure grounds upon which to base any assertion as to whether it is, as some say, an accidental coincidence, or whether it expresses some special law of the development of the earth's surface.

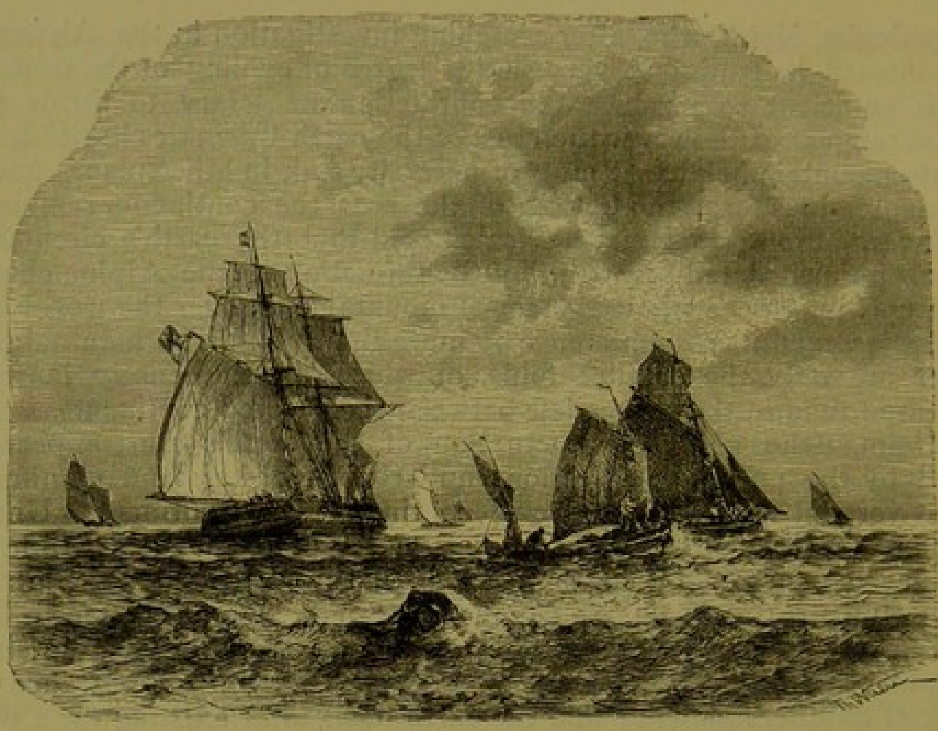
When we consider the greater volume of the sea in comparison to the land, and the inconsiderable average height of the land above the sea, and when we see how the mass of water, true to its levelling tendency, is always endeavouring to engulph all the land within its abysses, and to spread in one unbroken flood over the whole globe, we recognize how significant is this slight elevation of land over water. If the average height of the land above the sea level were diminished by only 550 yards, organic life would be driven back into very narrow limits; and if, on the other hand, the average height were raised in the same slight proportion, the consequences to human life would be no less disastrous.

We ask then naturally, what made the dry land rise thus above the waters? and what force preserves it from the incessant and pitiless attacks of the opposing element? Unless we appeal to mysterious forces which act from time to time, and then immediately vanish from the universe, we are compelled to ascribe this rising of the land above the surface of the waters to occurrences which took place when our globe was cooling down from its condition of liquid fire. The celebrated American geologist, Dana, was probably the first who put forward the hypothesis, that the earth's centre must have shrunk and contracted in this process of cooling, and so caused its outer crust to split open in rifts and fissures, a process which may be seen in the peel of an apple, of which the core is dried up. His hypothesis was tested by the

Swiss geologist, Heim, who, after searching investigation in the Alpine range, fully confirmed its truth. A very slight degree of cooling of the central substance is sufficient to produce the contraction necessary to throw up the mountain ranges. If however the crust of the earth "wrinkles itself" here and there into mountain heights, it must of necessity sink in other places, and these hollow depressions form the bottom of the seas, the continents remaining in their places. Professor Heim has calculated that the earth's circumference has been diminished only by $\frac{1}{5000}$ by the formation of the Alpine chain, and that the uprising of the whole system of mountains all over the world has not at present lessened its circumference by more than $\frac{1}{100}$. The mountain chains moreover are only the smaller folds, of which the immensely larger concavities are found in the spaces left between the severed continents. "Thus," writes Heim, "the perpetual fluctuation of the earth's crust appears to be imparted by the unequal depressions and risings of the land manifested in the great vertical rending asunder of continent from continent. Until this contraction ceases, neither rest, levelling, nor equilibrium is possible. The Alps themselves are only a local phase of this universal law of contraction, immeasurably great and valuable for our researches, but small even to insignificance in comparison with the earth as a whole. Their sudden uprising was but a moment in the history of our planet; their sudden disappearance will be the work of another moment; and the earth itself, after existing for a while in space among its kindred stars, is destined to vanish into nothingness between the eternity of the past and the eternity of the future."



MOUNTAIN AND SEA LEVEL.



CHAPTER III.

WATER.

"WATER is the beginning of all things. All things arose from water, and to water shall all things return." So spoke Thales of Miletus, and such was the grand part assigned by him to this element in the scheme of the universe. Seneca, the Roman philosopher, said, "If the whole world were to be dissolved in flames, nothing but water would be found to remain after the flames had died out, and within that water would lie hidden the germ of a new creation; for fire is the destructive, water the creative principle." Other philosophers, without absolutely claiming for water the right to be considered the fundamental essence of matter, yet arrogated for it a very high position, declaring that, together with earth, air and fire, it was one of the essential elements of matter.

It was reserved for the eighteenth century to point out the inaccuracy of these opinions, when Cavendish and Lavoisier proved that water was itself a composite substance made up of the two gaseous elements, oxygen and hydrogen. Everyone knows that water, according to pressure and temperature, appears either as a fluid, as vapour, or as ice; that it not only dissolves certain solid substances, but also absorbs gases within itself; and that it is chiefly by the solvent power of water that the chemical processes of the world are carried on. Without water, the existence of the animal and vegetable kingdoms would be impossible; and where, as in the sandy deserts, water is absent, life is vanquished, and death reigns supreme.

The peculiarity by which water receives within itself large quantities of atmospheric air, absorbing both its component parts, oxygen and hydrogen, is of great importance. The latter substance prevails in its composition, and this close affinity between water and hydrogen exercises great influence upon the organic life found in water. If the water is boiled so as to destroy the organic substances within it, and is then allowed to grow cold, fish thrown into such water will die in a short time. When water is heated from freezing point, it does not at once, like other substances, expand and become specifically lighter, but it contracts more and more to a temperature of 36°, growing specifically heavier, and not until it has exceeded the above temperature does it decrease in density. In freezing, water gives out the absorbed air and any dissolved salts. Pure water, unmixed with air, does not immediately solidify when it has reached freezing-point; on the contrary, it remains in a fluid state as low as 15° below freezing; but at this temperature the slightest shock or disturbance will occasion it to freeze.

Water is by no means colourless, but has, according to Bunsen, a pure blue colour. The above-named chemist observed the colour by looking through a column of water, about two yards long, at some pieces of white porcelain. Wittstein has also shewn that this blue colour is the purer in proportion to the absence of organic substances in the water. As the number of these substances increases, the water gradually changes, first to green, and then to brown. Water of atmospheric origin is also blue in its solid condition of snow and ice. The glaciers of the Alps and of Iceland assume this colour, while the neighbouring streams flowing from the glaciers are tinged with green.

The purer the water is, the less it disturbs the light falling through its surface, and therefore a mass of absolutely pure water would at a great depth be perfectly black, and only show a reflection of the light upon its surface. For if a ray of light falls through a narrow rift into a dark room, we can only trace its way by the particles of dust which are suspended in the air. If the air were quite free from dust, we should not be able to trace the path of the ray, because we cannot see the ray itself, but only the particles which it illumines. If a flask of water is examined by the aid of electric light, it is at once found that, the more impure is the state of the water, the more clearly we can see the light passing through it. It was in this way that Professor Tyndall demonstrated that even the filtered water provided by the great water companies for the use of London was very far from being really pure. He let fall a ray of electric light on some glass bottles of water, and in every case the path of the ray could be distinctly traced, while in some cases the water looked like thick soup.

Of course this method of analysis only shows the presence of solid particles in the water, and does not take into consideration the impurities which it holds in solution. If one proceeds to compare the water of certain natural springs with water which has been purified by any artificial process, the relative purity of the former is most wonderful. No mechanical contrivance as yet discovered by any of the great companies charged with providing the water for our towns and cities can furnish water of anything like the purity of that found, for instance, in certain parts of the Lake of Geneva. When Tyndall sent the electric ray through a flask of this water, nothing could be seen but a very faint blue line.

A theoretical method of purifying water is to let it stand until all the solid particles which it contains have sunk to the bottom. Unfortunately, this method is practically impossible. Leupold made the experiment in Bordeaux with some water drawn from the Garonne at high water, and found that the liquid, after standing for ten days absolutely undisturbed, had not recovered its natural clearness. The heavier substances fall very quickly to the bottom, but the lighter particles sink with exasperating slowness.

The process of filtration is now generally applied for the purpose of purifying water, without, however, as we have said before, being able to attain such a degree of purity as that already possessed by several springs. In choosing places, therefore, with a view to public reservoirs, regard should always be had to the presence of good spring water, and the facilities for its conveyance to the reservoir; and these considerations should outweigh those of cost. It is only when such an arrangement is absolutely impossible that the use of filtered water is justifiable.

The purest water is the best fitted for the human race, and the saying of Pliny, that the water for man's drinking ought to look like air, is borne out by all experience. He therefore set great store upon the water which, "by the goodwill of the gods, had been vouchsafed to Rome." The spring from which this water is supplied rises in the mountains of Pelignus, and flows through Lake Fucinus. It was first used to supply the city with water in the reign and by the command of Ancus Martius, and up to this day it furnishes water for a part of the town. In Persia the water of the river Choaspes was looked upon as the purest, and the Persian kings had it sent with them on all their journeys.

But the old truth that pure water is best for man has met with unbelievers and assailants. To bring forward one remarkable example, the German poet Adalbert van Chamisso relates that Captain van Kotzebue, who was in command of the brig *Rurik*, on a voyage round the world, forbade any filtration of the stagnant drinking water, because he was of opinion that by such treatment the water would lose its nourishing properties, and become less wholesome. Arago also tells us of certain admirers of foul water who based their predilection upon the plausible statement that sheep never drink out of the pools which they find on the wayside until they have trampled the ground, and stirred up the mud to mix with the water. Rain-water collected from a clean surface meets every requirement which can be sought for in good drinking water in a very high degree. The ordinary filtration of river water, it must not be forgotten, affords but a very slight and doubtful protection against organic impurities. The smaller filters, such as are sold for household use, with charcoal or porous stone, are infinitely more efficacious. Fresh charcoal removes all organic impurities in a very satisfactory manner, but it should be renewed at intervals of from three to six months, according to the purity and quantity of the water to be filtered. The Commission of Inquiry instituted in England for this purpose found that the use of a sponge-shaped iron-stone answered better than any other material; for, belonging, as it does, to the kingdom of inorganic matter, it was superior to charcoal, and continued its work of cleansing after being in daily use for eight months; while charcoal, in the course of time, itself produces certain of the lower forms of organic life. Thames water, filtered through the iron sponge, was rendered almost equal to good spring water.

Water, being a composite substance, can only have appeared upon our globe at a certain period of the latter's development, when perhaps by some electric force it flowed from the gaseous substances of which it is made. The question has been asked whether the mass of water now to be found upon the globe is as great as it was in the days of its primeval history, or whether there has not been a gradual decrease and loss. This question is of great interest, but any satisfactory answer to it is, at the present time, impossible.

It is certain that in consequence of the affinity existing between water and minerals, a considerable part of the liquid element is imprisoned in mineral substances. The present crust of the earth contains within itself great masses of water and of the component parts of the atmosphere, and in the primeval ages of our world these parts helped to make up the ocean and the atmosphere of that epoch. But who can prove that this process of absorption has not long since reached its utmost limit ?

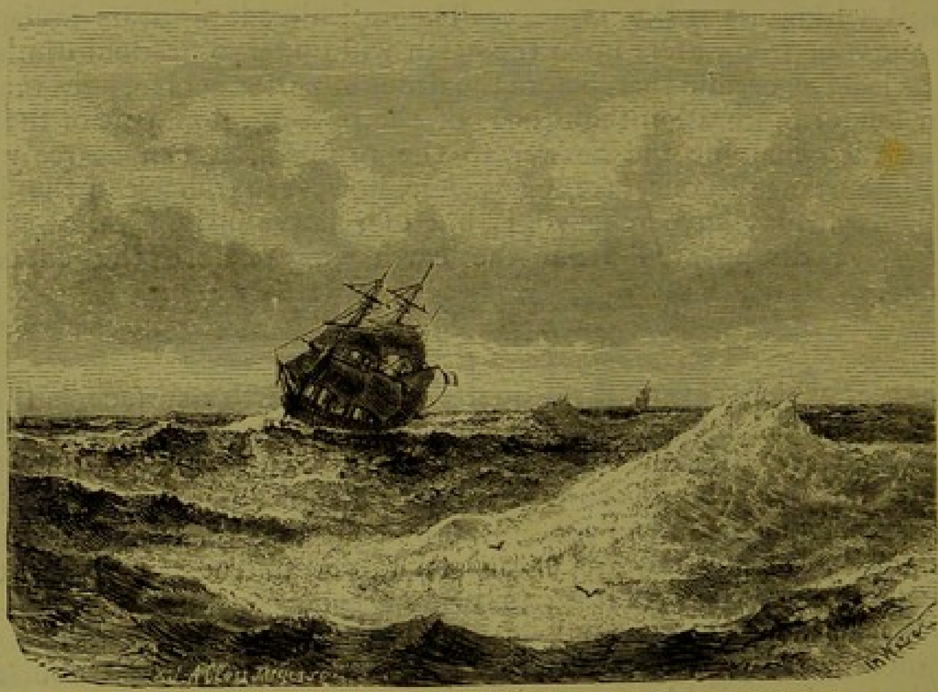
Hypotheses have been put forward as to a former higher level of the sea, but nothing approaching to certainty has been reached upon the subject. On the other hand, it is certainly remarkable that our neighbour, the moon, shows upon its surface the clearest indications of former ocean beds, while at the present day no trace of moisture, no substances analogous to our seas and lakes, are to be found upon it. This fact is made much of by those writers who predict for our earth a period of absolute drought,—a time in which all the seas will be chemically united to the framework of the globe, and for ever imprisoned within its rocky masses. Theoretically, it appears indisputable that the mass of free waters upon the earth will undergo gradual diminution; but it is at least as certain that, before the drought period sets in, ages must pass away, far longer in duration than those of the past development of the world. Whatever then may be the answer to the problem, it can scarcely be of practical importance to our race, whose age, however far back in the history of our planet it may have reached, is but of relative insignificance, and will probably have disappeared from the earth long before the catastrophe anticipated.

The Sea.

The sea, which covers three-quarters of the earth's surface, is the great reservoir for all the moisture which circulates through the world. From it arises all the water carried over the land, and to it this water returns through myriad channels. Nothing is so well calculated to present a picture of infinity as the aspect of the boundless sea. But to call the ocean, as is sometimes done, a "desert waste of waters," is misleading and untrue. The desert waste is hostile to all life, while the sea may almost be considered the mother of organic life. Like the dry land, it forms a world of itself, immense and mighty, inexhaustible in its riches, affording shelter, home and nourishment for countless and manifold forms of life.

In the present day we divide the sea into five great oceans, and this classification is so familiar to us all from our earliest school-days, that we can scarcely imagine its ever having been different. But, as a matter of fact, the most chaotic confusion prevailed not so very long ago as to the distribution of the seas in their oceanic basins. The present division only dates from 1845, and was agreed upon at a meeting of the Royal Geographical Society in London. According to the decision of the Commission then assembled, all the water between the two polar circles, Europe, Africa, and the meridian of the Needle Cape, America, and the meridian of Cape Horn, is called the Atlantic. The Indian Ocean is bounded by the southern arctic circle, the meridian of the southern cape of Tasmania, and the meridian of the Needle Cape. The Pacific Ocean, otherwise called the Great or Southern Sea, ends in the north in Behring's Straits, in the south in the polar circle, while its eastern and western boundaries are the same as those of the Atlantic and Indian Ocean. The two Arctic Oceans are comprised within their respective polar circles.

The present formation of the ocean beds is probably, on the whole, a very ancient one. The course of thousands and tens of thousands of years has, it is true, brought with it certain changes of detail; and geology shows that in earlier periods of the earth's development the ocean rolled over several tracts of our present continents; and that, on the other hand, vast masses of land now lie buried in the depths of the sea. We learn, for instance, from certain geological data, that at a remote period of time—the so-called Jura period—a mighty river flowed through the north-west part of Europe, the deposits of mud from which form some of the present scil of England. If the size of the river is calculated from the volume of earth and refuse sent by the current, we are led to believe that the stream must have equalled in breadth and depth any of the giant rivers of the present day. But the great river and nearly the whole course of its channel have long since disappeared; its delta lies buried under the waves of the North Sea, and the outlines of the European



SEA WAVES.

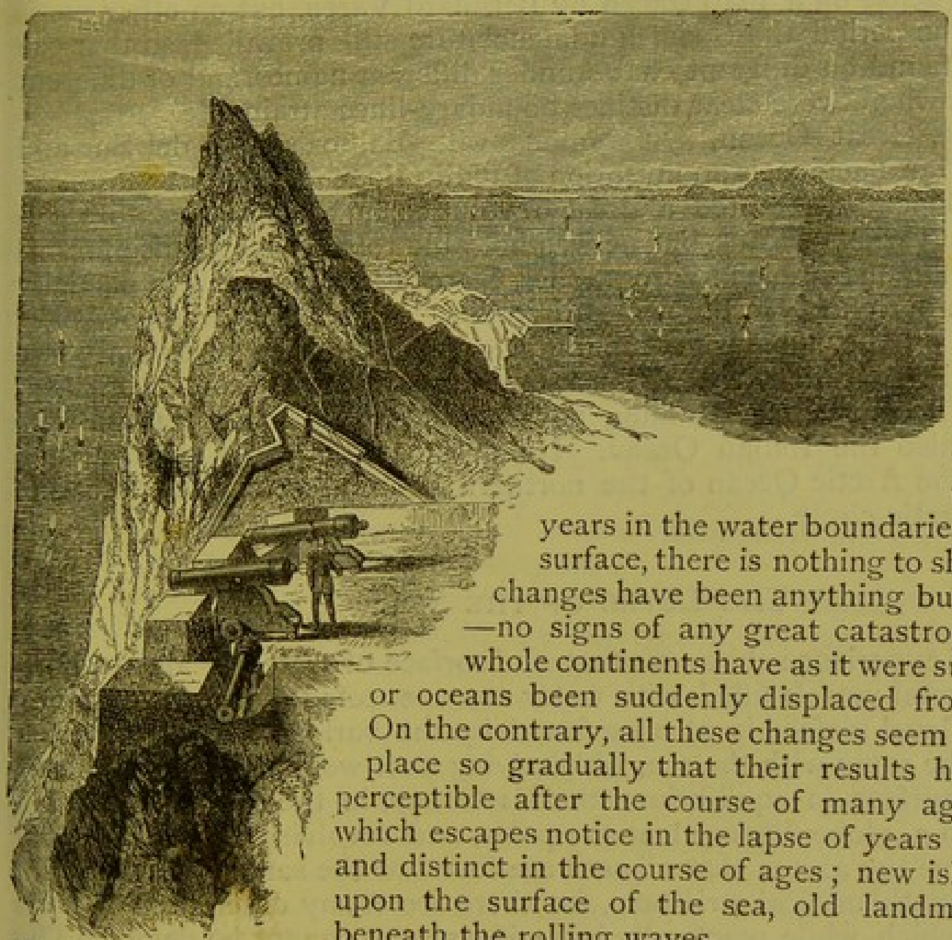
continent have undergone such a total change, that we have no indication to guide us as to the probable course of the gigantic stream.

Similar and equally great have been the changes in the Indian Ocean: at least, it is believed, from the similarity of animal and vegetable life in the islands of Madagascar and Ceylon, that they were formerly joined together, and formed part of a great continent which is called Lemuria, the mountain peaks of which still project above the surface of the ocean in the form of islands. And if we turn nearer to Europe, we find that the shallowness of the sea between Africa and the island of Sicily seems to indicate an earlier connection between the two continents of Africa and Europe; indeed nature has not yet desisted from its efforts to close up the gulf torn asunder between them. Twice have rocks appeared above the surface, violently thrown up from the submarine mountain range, dashing round them ashes, volumes of water, and torrents of burning stones, but forced at last to yield to the violence of the waves. And similarly the narrow Straits of Gibraltar, inferior in width to

A STORM AT SEA.

the mouth of many a river, are only of geologically recent creation, previous to which Africa and Europe formed one great continent.

But it is most unscientific to bring forward, as some writers have done, in support of this theory, the fact that there are found upon the Rock of Gibraltar certain kinds of monkeys, living proofs of the former union of the continents; for whatever may have been the alterations wrought during the slow advance of thousands and thousands of years in the water boundaries of the earth's surface, there is nothing to show that these changes have been anything but very gradual—no signs of any great catastrophe by which whole continents have as it were sunk in a night, or oceans been suddenly displaced from their beds. On the contrary, all these changes seem to have taken place so gradually that their results have only been perceptible after the course of many ages. For that which escapes notice in the lapse of years becomes clear and distinct in the course of ages; new islands are seen upon the surface of the sea, old landmarks are lost beneath the rolling waves.



THE ROCK OF GIBRALTAR.

The division of the ocean into different seas ranks among the oldest problems of geography. The geographers and map drawers of old times used to divide the watery veil of the earth into various parts, and call it by various names. In classic times and in the middle ages the nomenclature was very simple. The ocean flowing round the world was merely divided into two parts, east and west, under the names, Oceanus Orientalis, and Oceanus Occidentalis. Besides these divisions, writers recognised the Mare Internum (the present Mediterranean) and a Mare Externum. The idea of one single ocean stretching from the western and eastern shores of the continent was accepted even by Columbus, who always in his letters to the Queen speaks of "las mar Oceana."

It was not until Magalhaen had sailed round the world, and introduced a wholly new conception of its construction, that scientific men were forced to find names for the new tracts of water; and even then a generation had to pass away before the new nomenclature was generally accepted. In the middle of the 16th century, when Sebastian Münster wrote his Cosmography, we find these names for the first time, and strangely enough in the original Spanish forms. The Indian Ocean appears as the Mar di India, together with a Mar del Zur, and a Mar Pacifico, while the Atlantic appears as the Mar del Nort.

The name Atlantic was originally limited to the tract of sea to the west of the Straits of Gibraltar; in 1569 it was extended by Gerhard Mercator, in his famous projection, as he called his map of the world, to what is now known as the North Atlantic Ocean, and it was only in 1650 that it was used in its present sense for the whole sea reaching from America to Africa. It is found in this modern sense on a map traced by Bernhard Varen, but on other maps and charts of the period the Spanish nomenclature still prevailed, so that the same ocean is found on different charts under different names, and of different extent; and nowhere were clear distinct boundary-lines attainable.

The name, Great Ocean, synonymous with Balboa's Mar del Zur and Magalhaen's Mar Pacifico, is an invention of Philip Buache, and dates from the year 1752. Buache attempted a great revolution in the nomenclature and divisions of the various oceans, but he was not able to gain acceptance for his system. The famous French hydrographer, Claret Fleurien, was also partially unsuccessful in his efforts in the same direction. His division was not based like Buache's on the submarine mountain ranges; he recognised only two oceans properly so called, the Atlantic and the Great Ocean; the latter, according to his system, containing not only the Pacific, as Buache also asserted, but also the Indian Ocean. He designated as seas smaller than these oceans the Arctic Ocean of the northern hemisphere and the ocean of the southern arctic circle.

The Level of the Sea.

Our daily experience shows us that the surface of water is always horizontal. If several vessels filled with water are connected by means of pipes, an equality of level surface is at once found by the various masses of water. It is exactly the same with the sea, which, lying as it were in a gigantic basin, preserves its surface in equilibrium, that is to say, in the same form which corresponds to a globe flattened at the poles, and revolving round a central axis. Of course the axiom that all seas are found at the same level must not be pushed to mathematical strictness, for there are many differences of level in the ocean, which, while practically insignificant, yet cannot be denied. The land itself is a reason for certain of these slight local inequalities of the sea level. The attraction exercised by the masses of the land upon the sea is of course stronger upon the water nearer the coast than upon the central waters. This is indisputable, but we are unable to form any accurate idea as to the extent of the inequality, because we have no instruments suited for direct measurements. It has been calculated that, owing to the attractive power of the South American continent near Callao, the surface of the South Sea must be 155 yards higher than the water three or four hundred miles from the coast. If, then, that power of attraction were ever to cease, the waters of the sea would retreat, and leave the coast standing 155 yards high above the new surface of the water.

It has been attempted to determine the difference of level between two oceans by direct levellings across the isthmuses of Suez and Panama. The investigations at Suez have shown that the difference of level between the Mediterranean and the Indian Ocean is scarcely perceptible, for the current in the Suez Canal is neither very marked nor constant in its direction. Between Suez and the Bitter Lakes the current at high tide flows from south to north, and during the ebb tide from north to south. In the longer tract between Port Said and the Bitter Lakes the current varies with the seasons of the year. In winter the overplus of water brought by the flood tide from the south causes a deflux in a northerly direction towards the Mediterranean. During the summer, on the contrary, when 8,900,000 cubic yards of water are daily carried off by evaporation, out of a mass of 1,907,000,000, or in other words, when the daily level of the sea sinks by one-tenth of an inch, the deficiency is supplied by a current setting in from north to south, that is, from the Mediterranean; and this extra current meets the regular and ordinary current from south to north in the Bitter Lakes, when it is high tide in the Red Sea.

Only a very slight difference is found near the Isthmus of Panama in the depths of the Atlantic and Pacific Oceans. A direct measurement, carried out by order of Bolivar in the year 1828-9, proved that the South Sea at Panama was only $1\frac{1}{5}$ yard higher than the Atlantic near Chagres. And very careful and accurate measurements along the Pyrenees have established the conviction that the Mediterranean Sea, along the French coast, has the same level as the waters in the Bay of Biscay. This measurement, however, must only be considered as applying to certain average conditions; for under certain local and temporary circumstances the sea level is capable of great inequalities quite apart from any tidal influences. These fluctuations of the sea level are generally connected with the direction of the wind and the pressure of the atmosphere, and in the Baltic they are always regarded as unfailing signs of a change of weather.

The fluctuations of level in the Red Sea are especially interesting, and have been treated at length in the writings of the famous African traveller, Schweinfurth. The fishermen along the Egyptian coast have a saying, "When the Nile sinks, the sea rises." The most decided fall of the high water in the Nile occurs, in Egypt proper, on an average, about the middle of October. At this time the salt works along the Nubian coast are abandoned, the pearl fishers begin to be busy, and the fishing trade is much hampered. This period extends over the coldest month of the year, and is distinguished by the persistent height of the sea level. As accurate measurements cannot be obtained, we will assume that the minimum amounts to two feet; this would be quite sufficient to increase the effect of the tide to such a degree that along the flat, low-lying Nubian coast, where, owing to the heat and dryness of the north wind, salt is left by the ebb tide in sufficient quantity to leave a residuum after the next flood tide, a rise of two feet would make it impossible to carry on the work. The period of which we are speaking lasts from October to April, and the height of the water is hostile to the fisher folk and to every one whose vocation obliges him to work on the coral banks at low tide; even the diver, whose trade it is to seek for pearl shells, is forced to take this phenomenon into his calculations. Not until the end of April is the level of the sea so far restored to its former condition as to allow the greater part of the coral banks to be traversed at low tide. At the same time the heat gradually increases, and renders it possible to carry on the salt works, while the hot north wind replaces the south and south-westerly winds which have prevailed during the high level of the sea.

It would be vain to seek for any satisfactory explanation of these fluctuations, if the state of the winds and the seasons of the year on the one hand, and the situation and shape of the Red Sea on the other hand, did not come to our aid with valuable hints for our guidance; for, with a length of about 1,400 miles, the Red Sea is nowhere more than 230 miles broad, and in the Straits of Bab-el-Mandeb it narrows to the width of only ten miles. The whole length of these narrow straits offers free course to the northerly winds which blow along their surface from one end to the other; and if we turn to consider the effects of temperature, we can at once perceive how great must be the loss of water by evaporation in these narrow and confined seas during a given space of time. Such a loss, helped by the narrowness of the straits, and by the prevalence of the hot north winds which prevail during the summer season, must exercise a sensible influence on the current of the Indian Ocean through the Straits of Bab-el-Mandeb, and effect a depression of at least two feet in the sea-level. At any rate, there is nothing to contradict the general belief that, even under unfavourable circumstances, and when the south winds and equinoctial spring tides occasion a short interruption, the rising of the water of the southern extremity of the sea distributed over an area of about 675 miles, could easily amount to two feet.

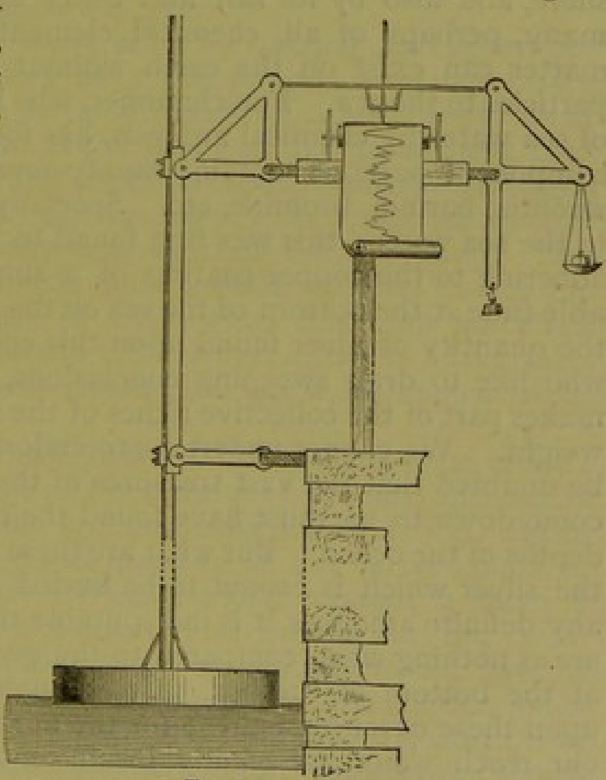
Occasional sudden fluctuations of surface level have been noticed in inland seas and lakes. The best known phenomena of this kind are the so-called shallows of the Lake of Geneva. This lake has been observed on stormy days to rise suddenly to a height of from four to five feet, as has been described by Saussure, and then as suddenly to sink again, and the alternate rise and fall have been known to continue for hours. On the 3rd of August, 1763, at about five o'clock in the evening, the above-named naturalist saw the level of the lake sink $4\frac{1}{8}$ feet in fifteen minutes, then rise $4\frac{7}{8}$ feet within the next ten minutes, and sink again $5\frac{3}{4}$ feet in the following twelve minutes. The rising after this third oscillation was only $3\frac{3}{4}$ feet in eight minutes, and the ebb which followed was very slow. The previous day had been extremely hot, at three o'clock a violent thunder-storm had broken over Geneva, and although the sky was covered with heavy clouds, scarcely a drop of rain had fallen. The phenomenon was noticed at both ends of the lake, close to the mouth and near the passage of the Rhone.

Similar fluctuations have been noticed in the Lake of Constance, where the rise and fall are known as the *Ruhssen*. They occur also in the Mediterranean Sea; at least, the indications of the self-registering apparatus for measuring the tide at Malta have clearly marked such irregular fluctuations.

A strange phenomenon was observed at Flamenville in Normandy on the 13th of July, 1725. The sea was calm, the wind blowing lightly from south south-west. At three o'clock the sea began to rise, the rise in this kind of tides being about ten feet along the Norman coast. It had already risen to the height of five feet, when suddenly, between six and seven o'clock in the evening, it retreated five feet, and in less than a quarter of an hour returned, not to its former height, but ten feet beyond it; that is, five feet above the highest point which it should have reached. In half an hour it sank, and regained the height of five feet which it had reached before it began its irregular oscillations. At seven o'clock it proceeded in the regular advance of the ordinary tide, without deviating further from its usual order. This occurrence was strictly confined to Flamenville, and was noticed at none of the neighbouring coast towns of Rozel, Charteret or Cherbourg.

In 1784, Loch Tay, a small lake in Scotland, was the scene of sudden and unexplained alterations of the surface level. On the 12th of September in that year, about nine in the morning, the waters of the lake were observed to be violently agitated near the coast of the village of Kenmore (56° 35′ north latitude). A little to the north of this village a river flows out of the lake, and to the south is a creek of about 900 yards long by 1,100 wide. This small creek is scarcely more than thirteen to twenty-six inches deep, but it rushes direct toward the lake itself. It was observed that at the end of this creek the water suddenly retreated, and returned within five minutes. In the course of a quarter of an hour this oscillation was twice repeated. Then the water suddenly rushed in two contrary streams, running exactly east and west, across the creek; and when it came to the place where the ground sinks, it rose like a wave $1\frac{5}{8}$ yard above its usual level; while the bottom of the water was left dry to a distance of 437 to 546 yards from the margin. When the two contrary streams met, a loud rush of water was heard, and foam was seen on the surface. The strongest force of the wave came from the eastward current, and when it had reached its greatest height it flowed slowly westward, and gradually disappeared. In proportion as the wave spent itself, the water returned with a certain degree of force, and exceeded its usual limits by twenty-seven to thirty-two yards, then it retreated for about fifty-four yards, returned again, and continued this alternate rise and fall for two hours, the ebb and flow succeeding each other at intervals of about ten minutes, and gradually decreasing until the water had regained its usual level.

While all this was happening in the creek south of Kenmore, the river to the north of the village was seen to flow backward. The sedge which was bent down in the direction of the river's ordinary course turned in the contrary direction, and the bed of the river was left dry for about $4\frac{1}{4}$ yards on each side. Under a bridge about 328 to 437 yards from the village the stream ceased, and the river bed was seen where eighteen inches of water had previously been. During the whole of the time the phenomena lasted the weather was perfectly fine, and the barometer stood at twenty-two inches. The same occurrences were repeated, but in a slighter degree, at the same time of day during the next five days. After that time something analogous was noticed sometimes in the forenoon, sometimes in the afternoon, until the 15th of October, when the lake resumed its normal appearance. In spite of close inquiries, no shocks of an earthquake could be ascertained as having been noticed in the neighbourhood.


THE LIMNIMETER.

Saussure ascribed the fluctuations of the Lake of Geneva to the pressure of the atmosphere. The surface rises when the pressure is diminished, and sinks when it is increased. Vaucher gave this theory his full approbation. More recently the fluctuations have been studied afresh and very carefully by Dr. Ford. He caused an instrument to be set up on his estate, which is situated on the seashore at Morges, which was designed to register the slightest fluctuation of the sea level. We give an illustration of this useful instrument, which has received the name of Limnimeter. The apparatus consists of a *swimmer*, which can be raised and lowered; and by this movement the triangle is turned towards the left, and the centre bar of iron towards the right. Above the bar a pencil is placed in a vertical position, so that at every movement it makes a mark on the paper which lies below it. This paper is unwound by clockwork at a uniform rate of speed. If the pencil remains undisturbed, a straight line is made upon the paper, but if the swimmer is raised or lowered, the pencil is turned aside either to the right or to the left, and traces upon the paper a zigzag line, the points of which directly indicate the rising and depressions of the water.

By means of this instrument Dr. Ford has shown that the whole mass of the waters of the lake is set in motion by these irregular fluctuations, and that the movement extends along and across the surface. The longitudinal oscillations last for about seventy-three minutes, and extend from Villeneuve to Geneva, over a basin 79,789 yards in length, and having an average depth of 125 yards.

Similar irregular movements have been observed in other lakes, especially in Neuchatel, Brienz, and Thun, but they have not been accurately recorded because of the absence of proper instruments to register the rise and fall. Singularly enough, it was proved that the great earthquake of the 8th of October, 1877, which shook the whole district round the Lake of Geneva, and even set the bells ringing in Morges, had no influence upon the fluctuations of the surface of the lake.

The Water of the Seas and Oceans.

Sea water is distinguished from fresh water by the peculiarly fresh and invigorating smell which can be perceived even at some distance from the shore, and also by its salt and bitter taste. It contains slight quantities of many, perhaps of all, chemical elements; for it is obvious that no soluble matter can exist on the earth without sooner or later sending some of its particles to the sea. Forschammer, who has repeatedly tested the composition of sea water by chemical analysis, has found that, over and above its ordinary component parts, it contains twenty-seven elements, among which are boron, strontia, barium, bromine, etc. Specially interesting is the presence of silver in the sea water; this was first found to be among the other substances by its adhering to the copper coating of a ship which had been left for a considerable time at the bottom of the sea on the Pacific coast of South America. From the quantity of silver found upon this copper, it has been estimated by writers who like to draw sweeping conclusions, that the weight of the silver which makes part of the collective riches of the sea amounts to 4,000,000,000 hundred-weight. We cannot undertake to endorse this bold declaration; but it cannot be doubted that the vast treasures of the ancient world, so little of which have come down to us, must have found their way by some means or other to the depths of the ocean. But what are these treasures in comparison to the value of the silver which is *known* to be buried beneath the waves? Without giving any definite amounts, it is indisputable that the silver mines of North America are as nothing when compared to the quantity of this precious metal which lies at the bottom of the sea. Unfortunately it is no easy matter to lay hands upon these ocean treasures; for the amount of gold and silver which is within our reach would be wholly insufficient to defray the expenses of bringing it to the surface.

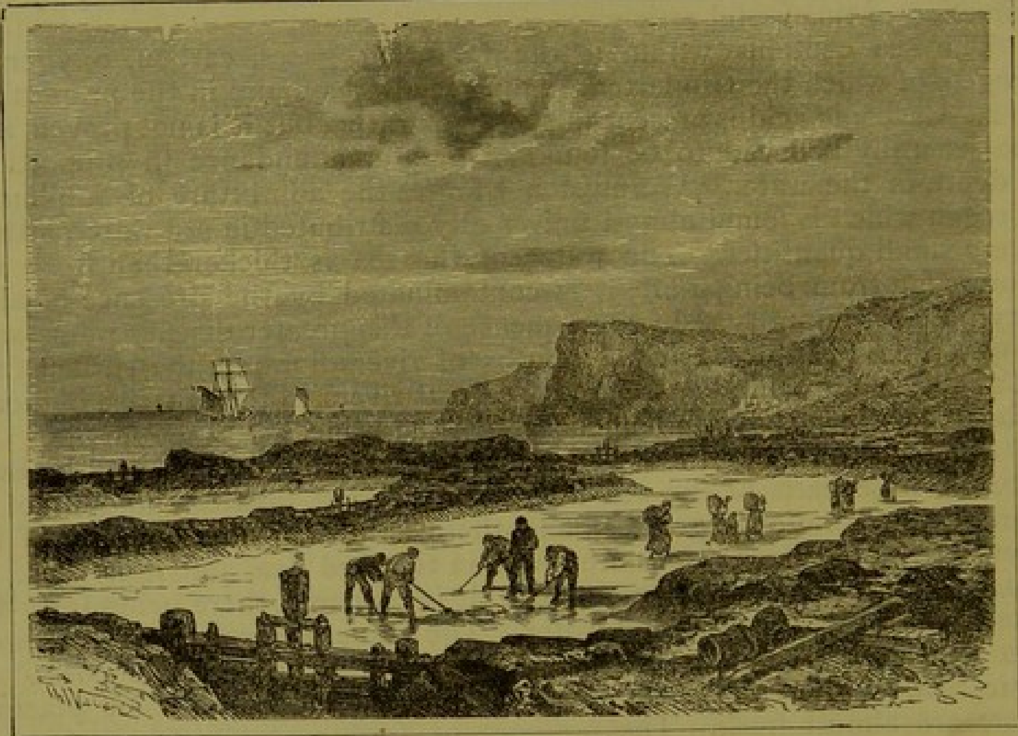
The amount of salt in the sea water is not everywhere the same; on an average it may be estimated at three per cent. Three-quarters of the sea salt is the ordinary cooking salt, the remainder being principally muriate of potash and bitter salt. It has been estimated that if all the cooking salt in the sea were gathered together in one solid block, it would measure 3,645 cubic miles. At any rate, the amount of the salt in the sea is greater than the amount of silver, and in many places salt can be collected in quantities by the simplest means. For instance, the sea water is allowed to run into shallow beds which are dammed off from the sea, and after evaporation a crust of salt is left and afterwards hewn out. The south of Europe is supplied in this manner with almost all the salt used there, but before being used the salt has to be purified. In Spain, 6,000,000 hundredweight of salt is taken every year; almost as much in Portugal, from which country great quantities are sent to England. It may be asked why England is forced to have recourse to Portugal, instead of making use of her own extensive coast line, but it must not be forgotten that rain and sunshine have their part to play in the production of this useful article.

The sea contains within it the following gases, carbon, oxygen, and nitrogen, of which the two latter are almost always found in the proportion of 1 to 2. Carbonic acid is present in great quantities, but it is not proved, as was once generally believed, to be found in greater abundance in proportion to the depth of the water. We must not forget the admixture of sulphuretted hydrogen which is found almost universally distributed in sea water, although in very small quantities. The water of the sea is thicker than fresh water because, far from being pure, it is contaminated by the presence of almost every possible impurity. In consequence of this greater density possessed by sea water, the fresh water at the mouths of rivers flows on the surface of the sea, and the ships which pass from the great rivers to the sea rise higher out of the water when they are launched upon the brine.

Salt is thrown out from the sea water both by freezing and by evaporation. Those parts of the sea therefore have the greatest amount of salt, where the evaporation is greatest, and there is little or no admixture of fresh water. Both these conditions are found in the Red Sea, and it is there, consequently, that the greatest amount of salt is procured, there being forty-three parts of salt to one thousand of water. The amount of salt in the Mediterranean Sea is also considerable, especially near the hot African coast. The Baltic Sea, on the contrary, has very little salt; indeed, in some places the waters are almost fresh. The presence of fresh water has been perceived even in the midst of the ocean, and Darwin tells us that after the heavy rains near South America the surface of the South Sea has been known to be perfectly fresh.

The question of the origin of the salt in the sea has been often raised; some attributing it to immense salt beds at the bottom of the sea, and others to its having been carried down by rivers, and gradually accumulating. As to the latter hypothesis, it is clear that a small quantity of salt is contained in fresh water, and remains in the sea after the water which brought it there is evaporated; so that, strictly speaking, the quantity of salt in the sea is increased by the influx fresh water. But those writers who would have us believe that the presence of salt in the sea is owing to the contribution made by river water, forget that the volume of all the river water in the world is as nothing in comparison to the immense mass of salt water. It has been shown by trustworthy estimates that all the rivers of the earth send, on the highest computation, only 4,557 cubic miles of water a year into the sea; and, as has been previously shown, the mass of water of all the seas amounts to 273,500,000 cubic miles; the fresh-water streams, therefore, would have to flow for 60,000 years to fill up the basin of the seas. This basin would then only contain fresh water, and millions of years would have to pass before the present amount of salt in the oceanic basin was accumulated. The famous Halley actually arrived at this conclusion, and even Buffon was very much inclined to agree with it.

Halley imagined that we could estimate the age of the ocean, if, indeed, we could not estimate that of the world itself, by the amount of salt in the sea. He asserted that the average quantity of salt to be found in fresh water should be tested by experiment; it would then be possible to calculate how much was yearly carried to the sea, and that amount, when compared with the actual quantity of salt in the sea, would give the number of years during which the rivers had run into the seas. It is not difficult to perceive the fallacy of this reasoning: we have only to remember that the present river



SALT-MAKING FROM SEA WATER.

system did not exist at the time of the creation of the sea, and that the amount of salt contained by the rivers is capricious and uncertain. Far more probable is the contrary supposition, which ascribes the presence of salt in fresh water to the effect of the sea; for at one period of our earth's development all the land lay submerged beneath the waters of the sea, which, in proof of its former presence, has left behind it those beds of rock salt which are being worked at the present day.

The popular idea that sea water, thanks to the presence of the salt within it, is less liable to corruption than fresh water, is utterly unscientific; for the waters of the ocean just as easily become foul as river water, and there are certain parts of the sea in which the stench of the decaying water is absolutely intolerable. This is especially the case in hot, windless regions, and certain stretches of coast land near these stagnant seas are infested with its pestilential vapours.

One of the curious puzzles presented to us by the ocean is the sudden uprising of fresh springs in the midst of the salt waves.

"On the south coast of the island of Cuba," says Humboldt, "south-west of Port Batabano, in the Bay of Xagua, but about two or three nautical miles from the coast, springs of fresh water rise, probably from hydrostatic pressure, from the bottom of the sea. They rise with such force that canoes do not venture to approach the fatal spot, fearing the violent crossway movement of the waves. Trading vessels sailing along the coast, and not wishing to land, sometimes visit these springs, and lay in a stock of fresh water in the open sea. The greater the depth from which they draw, the sweeter is the water. Very frequently the *Trichecus manati*, or river cow, a creature who cannot live in salt water, is found within these springs. This curious phenomenon, which has never been mentioned until now, has been carefully investigated by Don Francisco Lemaur."

Sea water varies considerably as to its colour and transparency. The ordinary colour is grey or greenish blue, according to the state of the sky overhead. But when the rising or setting sun is near the horizon, the surface of the sea is lighted up with a splendid gold colour, or magnificent rose and purple. All this variety of tints is caused by the reflection of the light on the surface and in the depths. The high seas are emphatically spoken of by our seamen as "*blue water*;" and if, as Captain Scoresby has done, any one looks at the sea through a long vertical pipe, so as to keep off as far as possible all side lights, blue is seen to preponderate greatly over every other colour. The colour naturally varies very much, according to the locality. Thus Scoresby, who sailed principally in the Arctic seas, being engaged in several whaling expeditions, mentions that in those regions the seas are frequently covered for miles with bands of green. In 1817, the sea, between 74° and 75° north latitude, and 2° to 14° east longitude, appeared blue and transparent; gradually it lost its clearness, and assumed a shade of grass green. These coloured tracts in the sea have sometimes very sharply defined outlines. Scoresby says that he once sailed through bands of pale green, olive green, and transparent blue in the course of ten minutes. The green colour is caused by myriad microscopic animalculæ, which serve as food for the whale.

Robert Brown says that the dark colour of certain parts of these seas is by no means to be ascribed to the presence of countless numbers of animalculæ, such as the Medusa and Pteropoda, as has been the generally received belief; for these creatures disappear completely at certain times from the surface of the sea, but the brown colour remains unchanged. The true reason of the peculiar colouring of the Greenland seas is owing, Brown tells us, to the presence of innumerable quantities of Diatomaceæ. The Medusa and other creatures feed on these minute algæ and in their turn become the prey of the whale, who is enticed by their presence in the districts known to sailors as the "black seas."

In the neighbourhood of Cape Palmas, on the coast of Guinea, Captain Tuckey found the sea of a milk-white colour. And on the 15th of April 1865, latitude 9° N., longitude 50° E., Captain Coste saw a milky fluid floating round his ship on the surface of the sea; by degrees it spread on all sides as far as the horizon, presenting strange contrast with the darker colour of the sky. When some of the liquid was examined on board ship, it was found to contain a number of microscopic animalculæ, and that the light issued from them. Captain Kingmann reports a similar occurrence which he saw in the Indan Ocean on the 27th of July, 1854. The sea was suddenly covered with the milky fluid over an extent of five or six miles, and looked as if it were covered with snow. The sky, in which no cloud was visible, appeared dark by contrast with the water, and the spectacle was peculiarly weird and imposing. When samples of the water were taken on board, they were found to contain innumerable slimy, worm-like creatures, which soon melted away.

Another appearance of the same kind was witnessed from the German war-steamer *Luise*, on the 9th of February, 1878. The commander, Captain Schering, reports as follows: "At the end of a clear and beautiful sunset, about a quarter to seven in the evening, the sea suddenly assumed a pale tint, and became in a few minutes as white as milk. The stars, which had just before been shining brightly, grew dim, and the horizon darkened. The sea looked exactly like a sheet of ice by moonlight, although the moon had not yet risen. The swell, which had been rather considerable before, now subsided; no more was seen of the white crests of the waves, and the noise of their advance could not any longer be heard. A thick fog twice settled down on the water, and lasted for a few minutes; the horizon was faintly discernible, and round the sky line the darkness increased. There was no phosphorescence visible on the water. When the moon rose at about a quarter to eight, the phenomenon gradually disappeared, the sea and sky resumed their usual colouring, and the stars recovered their brilliancy. We saw no recurrence of this phenomenon on the following days, and we were inclined to connect it with electricity. It had no influence whatever on wind and weather."

The colour of the sea water, which, as we know, is no inherent property of its own, but is due to other causes, has suggested names for certain seas, as, for instance, to the Yellow Sea, the Red Sea, etc. The Black Sea is so called, not on account of its colour, but probably because of the frequent fogs to which it is subject. The so-called Dark Sea, that is, the stretch of waters in the Atlantic Ocean near the islands of Cape Verde, takes its name from the dry vapours and the red dust which are sometimes encountered by sailors in those districts. According to recent investigations superintended by Hellmann, these waters are sometimes covered, for a space of 1,600,000 geographical square miles, with minute particles of dust, which lie for several days. This dust comes from the neighbouring desert of Sahara, and is carried seaward by the wind. On the islands themselves the sandy mist is frequently so dense during the prevalence of the east winds, that, especially in the morning, the coast is invisible at the distance of one mile.

The clearness of the sea water is at times wonderfully great. Columbus often expressed his astonishment at the transparency of the West Indian Ocean. It is said that at certain points glimpses of the bottom of the sea may be obtained at a depth of 273 yards. This statement is most probably exaggerated, as is also the assertion made by Wood, who says that in the neighbourhood of Nova Zembla in 1676, he distinctly saw the bottom of the sea covered with shells at a depth of five hundred feet. On the other hand, the coral banks of the Red Sea often appear so close to the observer, that he fancies the water can only be a few feet in depth.

This splendid view of the bottom of the sea, with the wonders it contains, is only vouchsafed to the favoured spectator under certain circumstances and in certain places; as a rule, the land beneath the sea is invisible, and even in very shallow water only betrays itself by the alteration of colour which it imparts to the surface resting above it; for the sun's rays suffer a constant and increasing loss of light as they penetrate beneath the surface, and this loss is so considerable that at a depth of from 328 to 437 yards the reign of absolute darkness prevails. Divers tell us that in the depths at which they are able to work the sea has a purple colour, and this fact was either known or divined by the poet Schiller, who, in his well-known ballad of the Diver, speaks of the purple darkness of the ocean depths.

It is true that microscopic animalculæ, decked out in brilliant green and red dyes, have been brought up from a depth of 3,750 to 7,500 feet, but this must not lead us to the conclusion that light prevails in the regions from which they came. The results of the deep soundings taken in the *Challenger* expedition point to wholly different conclusions. In the Atlantic Ocean, at a depth of 375 to 12,125 feet, crustaceæ were discovered with a strange structure of the visual organs. Now, as these animals had some sort of eyes, we must conclude that their dwelling-place was not wholly deprived of light, although to our perception the amount of light present would be indiscernible; and this theory is confirmed by the fact that the crustaceæ brought up from a still lower depth have no eyes at all.

One of the most beautiful phenomena among the many wonders of the ocean is its phosphorescence. This appearance is seen in all parts of the sea, but is most frequent and splendid in the tropics.

"This illumination of the ocean," Humboldt says, "is one of those natural phenomena which would arouse our admiration and wonder, if we could see it recur night after night for months together. The sea is occasionally phosphorescent in every zone; but he who has not seen this spectacle in the tropical regions, and more especially in the South Pacific, can form but a very imperfect idea of its grandeur and beauty. When a ship of war, impelled by a fair wind, cuts through the foaming billows, it is impossible to weary of the sight presented to the observer by the fiery play of the waves round the ship's side. Blue and red flames appear to dart like lightning flashes upward from the keel; and wonderfully grand is the spectacle of a school of dolphins playing among the waves in the dark tropical nights, and marking their path through the foaming waters by showers of intensely brilliant sparks and gleams of light. I have enjoyed this sight for hours together in the Gulf of Cariaco, between Cumana and the Peninsula of Maniquarez."

The famous Captain Cook, when on his voyage round the world, first saw this illumination of the sea on the 29th of October, 1768, four days after he had crossed the line on his way to Brazil; he compares the light to that of the electric flash in a thunder-storm, only that it was less vivid; and ascribed its origin to the presence of microscopic animalculæ. Towards the end of October, 1772, the same traveller saw the phenomenon on a magnificent scale near the Cape of Good Hope. "Between eight and nine at night," he says, "the sea suddenly began to shine. It was a splendid sight. As far as the eye could reach, the ocean was all on fire. Every wave flashed with phosphoric light, and the track left by the ship was brilliantly illuminated." Cook had several buckets of the water taken on board, and found it full of minute animals of gelatinous substance. When Finlayson, in sailing near the Prince of Wales Islands, saw the surface of the sea covered with myriads of infinitesimal creatures, so that it looked as if coated with greenish slime, he found that as night drew on the phosphorescence appeared in great splendour, and that it was sent out by the animals themselves. Horsburg and Riville also have seen the sea on dark moonless and starless nights white as if covered with snow, recalling the gleaming light of certain clouds under the influence of earth magnetism.

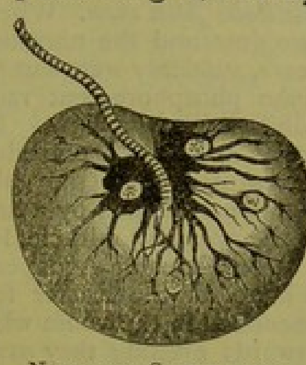
The most valuable information as to this lighting up of the sea has been obtained by the unwearied industry of Ehrenberg. It is proved from his observations, which were communicated to the Academy of Berlin in 1833, that the light is due to the free, conscious, and voluntary action of independent and often microscopically small organisms. The same authority tells us that the phosphorescence in the Arctic Sea is much less intense, because the surface of the water and the upper strata are generally sweet from the constant melting of the masses of ice. Below these strata the sea is full of fiery sparks. Ehrenberg also states that in the Gulf of Mexico phosphorescent animals have been found, whose existence in such numbers and over such a vast extent has modified the previous conception as to the impenetrable darkness of the sea's depths; and has given rise to the theory that even in the deepest part of the sea light is not always and wholly absent, but that there are either perpetual or periodical flashes of light sent for the help of

Life at the Bottom of the Sea.

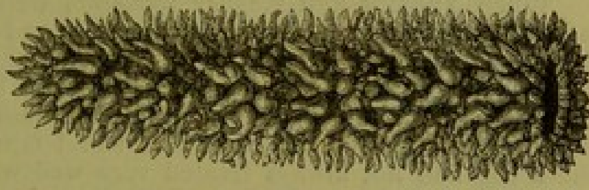
those creatures who possess eyes, and who by possessing them show that light of some sort must exist in their dwelling-place.

The most recent deep sea soundings have brought to our knowledge many species from the depths of the Atlantic Ocean, which were in the highest degree phosphorescent. Sometimes everything brought up by the net sent out gleams of light, and the mud was literally alive with sparks of fire. Can one wonder that, when this fact was brought face to face with that which tells us that there is no light in the lower depths of the sea, the theory was immediately put forward that certain organisms possess a light of their own, by which they are enabled to seek their food ?

The remarkable statement, often contested, that the light is the effect of an exercise of free will on the part of the creature possessing it, has by recent observations been placed beyond the power of doubt. Burmeister has frequently seen that these phosphorescent animalculæ only emit light when they come into contact with other bodies; if they are left undisturbed, they do not shine, and the light comes from the upper surface of their bodies. The latest enquiries have shown that almost all the lower forms of life in the sea, but especially the Acaleptra, Infusoria, Polypi, and Mollusca, possess the power of shining. Amongst the first-named class the *Noctiluca scintillans,* a wonderful little creature, not so large as the head of a pin, gives out a splendid radiance. Ehrenberg has also discovered that the *Protocharis,* one of the Infusoria, gives out sparks when irritated, first one by one, and then extending until the body of the animal shines with a brilliant greenish yellow light something like the flame of a lucifer match. The light given out by the Pyrosoma, a creature of cylindrical form, is so intense, that Von Bibra was able to read aloud from a small zoological manual the description of the animal to an invalid and bedridden friend by no other light than that afforded by the object of his study, the Pyrosoma itself.



NOCTILUCA SCINTILLANS. (*Magnified.*)



PYROSMIA, OR "FIRE DANCERS."

According to Quatrefages the seat of the light is to be found in the muscular substance of the feet among the Annelidans, while the Medusa send out a pale blue light from the organs by which they propel themselves forward. Among the *Oceania hemispherica* Ehrenberg asserts that the situation and number of the sparks of light correspond exactly to the cirri (soft filaments of the jaw) or organs which alternate with them. "The appearance of this light is a vital action, the whole light development of a life process which appears in the infusoria as a momentary spark of light repeated after a short interval of rest." Indeed, the fact that in most animalculæ the light is attached to some special organ speaks strongly for the close connection between the life process and the emission of light. But if we rise above this lowest class of animal life, and come to certain forms of shell-fish, we find among them species which have this luminous property, in whom this light is connected with a certain moisture, and shines on of itself. Even Pliny had observed this; for he says, "It is in the nature of certain Pholades to send out a gleaming light in the darkness, which is the brighter in proportion to the moisture they contain." Milne Edwards was able to confirm this statement by his own experience, for he immersed some of these animalculæ in spirits of wine, and saw a shining fluid drop from their bodies to the bottom of the flask, where it continued to shine.

This phosphoric light is by no means confined to sea water. Certain minerals, as, for instance, ponderous spar, and nitrate of magnesia, etc., shine in the dark, if they have been previously exposed to the sunshine; and it is sufficient to rub certain other mineral substances, such as dolomite and diamond, to enable them to shine in a certain degree.

But this kind of light is very different from that possessed by organic bodies under certain circumstances, the latter having the greatest similarity to the phosphorescent light of the sea.

This phosphorescence has often been noticed on the opening of old graves. Foissac relates that in the pontificate of Paul the Third, who was raised to the papacy on the 18th of October, 1834, an old monument was discovered on the Appian Way with the inscription *Tulliolæ filiæ meæ*. When the grave was opened, the corpse of Cicero's daughter crumbled into dust, and the narrative continues, "a lighted lamp, which had been burning for 1,500 years, suddenly went out." This statement is of course impossible, but it is probable that some phosphorescent radiance shining in the grave became suddenly invisible on the admission of daylight. Raulin tells us of bodies which have lain for a long time in the grave, and have shone with phosphoric light in their coffins. When the criminal Freburg was sentenced to the gallows after a long course of crime, his head was seen for many nights surrounded by a halo of light, and many of the Danes, ignorant of the natural causes of the apparent miracle, looked upon this as a sign of his innocence.

Fabricius de Aquapendente relates that in 1592 three of his pupils in Pavia had bought a lamb for the Easter festival. They had eaten half, and the other half was hung up uncooked in the room which they shared in common. What was their astonishment when towards evening they saw this meat send out a silvery light, *argentino splendentem nitore;* when it was touched, the light grew brighter, adhered to their fingers, and to every object with which it came in contact. One of them ran in terror to Fabricius, who soon arrived with many curious followers. The famous anatomist laboured in vain to convince the astonished crowd that the phenomenon they were witnessing was no miracle, but occurred in the ordinary course of nature.

When Thomas and Kaspar Bartholin were staying at Montpellier in 1641, a woman had bought some meat from the market, and hung it up opposite the foot of her bed. She awoke during the night, and, seeing a light, was afraid that she had forgotten to put out her lamp; but she soon perceived that the light which illumined the whole room came from the place on the wall where she had hung up the meat. At once she became filled with every kind of superstitious dread and fancy: she thought first of her late husband, whom she had not always treated very well when he was living; and then she began to imagine that heaven perhaps made choice of her house to be the scene of a great miracle. The neighbours came in to see the marvel with their own eyes, and among them Thomas and Kaspar Bartholin examined the shining meat. A portion of it was sent to Henri, Prince de Condé, the governor of the province, and it shone for three hours upon the table. The light was something like that of the stars, sometimes twinkling, sometimes sending out fine rays, and sometimes even in the shape of a cross. The fanciful ideas to which this phenomenon gave rise were quickly dispelled by the prosaic explanation given by the faculty of medicine at Montpellier.—*Foissac, Meteorology.*

More recently a similiar occurrence was noticed by Nuesch at Schaffhausen. "As I was working quietly in my room one evening," he says, "I suddenly heard a fearful scream from the kitchen—'A ghost! a ghost!' The servant maid had gone without a light into the pantry to fetch something she wanted from a table, on which lay a dish containing about half a dozen pork chops. I immediately proceeded to explore the mysterious chamber, but as I had brought a lighted lamp with me, I of course saw nothing unusual. I at once extinguished the light, and immediately the contents of the dish shone with such a vivid green light, that all present could recognize each other by the light sent out by the chops. Each separate piece seemed absolutely on fire, and the light was so strong that not only the minute but even the second hand of the timepiece could be distinctly seen. When we touched the meat, the light remained on our hands, and shone brightly for hours together; but if the hands were violently rubbed, it soon disappeared. On examination of this shining substance through the microscope, it was found to be composed of a number of minute, and for the most part globular, animalculæ; some, however, were octagonal and some cylindrical in form. If they were examined through the microscope at night, myriads of little streaks and points were seen moving to and fro. By daylight the meat presented no unusual appearance; it was quite fresh and healthy, and had no tainted smell—indeed, not the slightest sign of putrefaction could be detected."

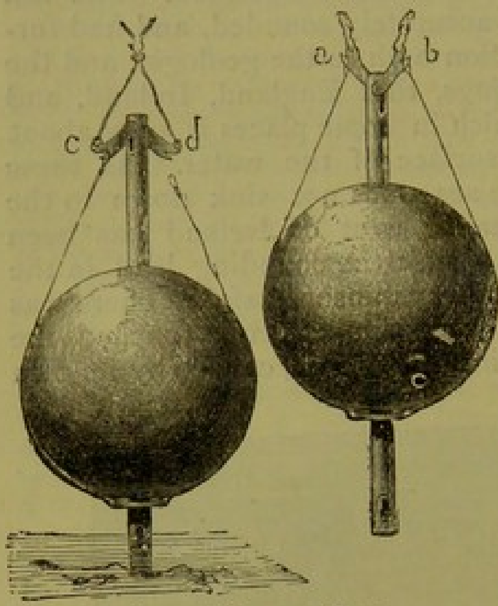
THE DEPTHS OF THE SEA.

Until a very recent date it has been impossible for science to penetrate the eternal abyss of ocean covered by its depths of water. Not long ago it was impossible to give any definite answer to the question as to whether the sea was only a few thousand feet deep, or whether the depths were to be measured by mile upon mile. All endeavours to penetrate the mystery remained unavailing; and it seemed as if the recess of the ocean would remain for ever veiled in mystery. It was only in the shallower ocean beds that trustworthy knowledge of their form and depth had been obtained. The sea round Great Britain, for instance, had been accurately sounded, and had furnished much interesting and valuable information both to the geologist and the geographer. It was shown by these soundings, that England, Ireland, and Scotland rest upon a submarine plateau, which in some places is only about the length of a church steeple below the surface of the water. As these experiments have proved, the bottom of the sea does not sink down to the depth of the ocean proper until some distance west of Ireland has been reached. Efforts have indeed been made to sink the sounding lead in the depths of the open seas, but the attempt was always unsuccessful. There was no sign to tell the experimenter on the ship when the lead had touched the ground; fathom after fathom of line rolled into the depth, carried by its own

THE DRAG NET.

weight, or by the force of the submarine currents. The line itself was lost at every attempt, for it was impossible to raise it again with the weight attached.

Under these circumstances the ocean was looked upon as an unfathomable abyss; and no computations as to its depth were accepted as final. Thus Lacaille thought that the average depth of the sea was 546 yards, and Laplace was of opinion that the ocean depths must be equal to that of the land, or very nearly so; Humboldt imagined its average depth to be 2,187 yards, and Young, one of the most acute physicists of modern times, estimated from calculations made as to the movement of the tidal waves, that the average depth of the Atlantic amounted to 5,460 yards. But all these calculations were based upon hypotheses, and only made the want of accurate data more keenly felt. A slight advance on the old system of sounding was made by having the line as thin as possible, and using a cannon ball for the weight. Of course it was not intended or desired to raise this weight again to the surface; and the great advantage gained was the sudden shock which announced that the bottom was reached, or at least the change of the speed in the descent of the line, which accomplished the same purpose. Brooke introduced great improvements upon this method by fastening the weight in such a manner that upon touching the ground it released itself.



BROOKE'S SOUNDING LEAD.

We give a drawing of Brooke's sounding lead. The cannon ball which is used for a weight is pierced through, and a thin bar is passed through the opening. At each end of this bar are two wings like the two parts of a pair of scissors, *a* and *b*; in these wings are notches, round which is placed the cord which suspends the cannon ball. As long as the line sinks, and a downward pressure is exercised upon it, these wings remain extended in their original position, and hold the ball in place; but as soon as the bottom is reached, the downward pressure ceases, the line sinks a little in consequence of its own weight, and the wings assume the position *c d*. This sets free the cord which keeps up the cannon ball; the latter rolls away, and the line, released from its weight, can easily be drawn up to the surface. Moreover, there is at the end of the bar an opening filled with tallow or goose quills. When the ball comes in contact with the ground, this bar sinks into the mud or sand, and the opening is filled with samples of the ground.

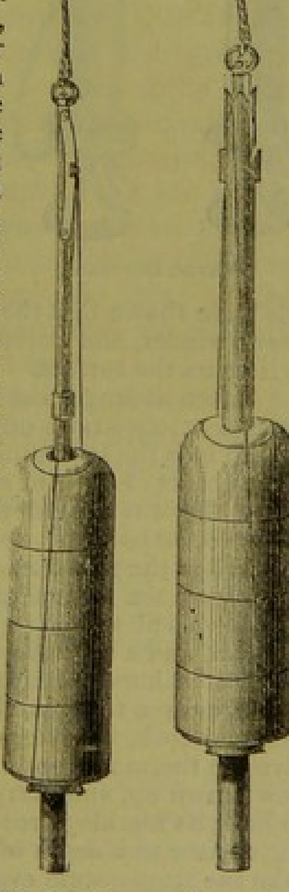
Notwithstanding its extreme simplicity, Brooke's sounding lead has rendered valuable aid to the exploration of the ocean bed. Of course, in process of time it has been further developed, and many improvements have been added, as, for instance, better instruments for seizing the samples of the ground have been introduced, thermometers for registering the heat of the water, and piano wire instead of rope are now generally used.

It is to the Danish geologist, O. F. Müller, that science is indebted for the idea of using trawls and dredges to bring to the surfaces more satisfactory evidence of the life within these lower deeps ; and by means of these improvements, Forbes was enabled to study more thoroughly the animal and vegetable life of the ocean. The whole apparatus, however, is of considerable weight, and requires steam power to work it; but when successfully used, its results are marvellous, in comparison with the attempts of past times ; for we read of the material of these once inaccessible ocean beds being brought to the surface by hundredweights.

Among the many expeditions which have aided the advance of natural science by their various researches into ocean life by means of deep sea soundings, the following deserve special notice. The steamship *Porcupine* explored in the Atlantic, in 1869, under Wyville Thomson and Carpenter, the objects of the expedition not being restricted to taking averages of the sea's depth, but embracing specially the study of life beneath the surface of the ocean. This branch of our subject will be treated more at length in the forthcoming part of the work ; at present we are speaking only of physical peculiarities, and specially of the depths of the ocean. It was the *Porcupine* expedition which discovered the steep descent of the Irish submarine plateau and this western abyss was explored more thoroughly by Daymann in the *Cyclops*.

But far more comprehensive were the results obtained from the great scientific voyage of discovery which carried its victorious course round the world under Wyville Thomson as the head of the scientific staff. This voyage was made by the English screw corvette *Challenger*, which left Sheerness on the 7th of December, 1872, and returned to Spithead on the 24th of May, 1876, having been absent three years and a half, and surpassed all the previous efforts towards a scientific investigation of the watery element. Until January, 1875, the *Challenger* was commanded by Sir George Nares, but when Sir George was appointed to the command of an Arctic expedition, Captain Frank Thompson succeeded to his duties. The corvette had to be wholly transformed for her new purposes, and only retained two of her heavy guns, and these she was never called upon to use during her peaceful conquests. On the upper deck was the steam engine of 18-horse power for hauling in the dredging lines, and all the instruments needed for the deep soundings. It is of course absolutely necessary that these deep soundings should be taken from the deck of a steamship; no sufficiently satisfactory results would be possible with a sailing vessel; for even in the very calmest weather the swell or surface current would suffice to carry the ship in a short time to a considerable distance from the place where the lead was thrown. Such a change of position would make it impossible to obtain a vertical sounding, and the intervals of time between each marking of a depth of 1,000 fathoms, which are the only means of registering the advance of the lead, would be faulty and irregular.

When soundings were to be taken, the sails were furled and the ship brought head to wind; the block fastened to the mainyard and a girt line sheered to hoist the accumulator. This accumulator consisted of several long stout bands of gutta percha, which could expand to a length of seventeen feet when subjected to a weight of seventy pounds on each band. In ordinary soundings, twenty of these bands are sufficient to bear the strain put upon the sounding line, and at the same time are sufficiently elastic to yield to every movement of the ship. The principal use of the instrument is to prevent the line from being over-strained and to enable it to resist any sudden shock. At the lower end of the accumulator, of which the separate bands were passed through holes bored in wooden discs, to prevent their becoming entangled, a block was attached, through which the dredging line passed. The end of the latter was then made fast to the gauging rod, which was weighted to facilitate its speedy sinking. Close above this rod was a moveable draw-flask and a deep water thermometer. At first the explorers made use of the so-called hydra, an instrument shaped like a long and hollow rod of metal, with a ring at one end to fasten the rope to, and at the other butterfly valves to prevent the mud inclosed from falling out. In the centre of each weight a hole was made, through which the rod passed, and the weights were suspended by means of a wire passed round them and over a button near the upper end of the rod; the tension of the wire pressing back a spring through a hole from which the button protruded. When the weights touched the bottom, they were raised a little in rebound, the tension was removed from the wire, the spring pushed it from the button, and, the wire falling, the weights slipped off, and the rod came up filled with the mud into which it had sunk.

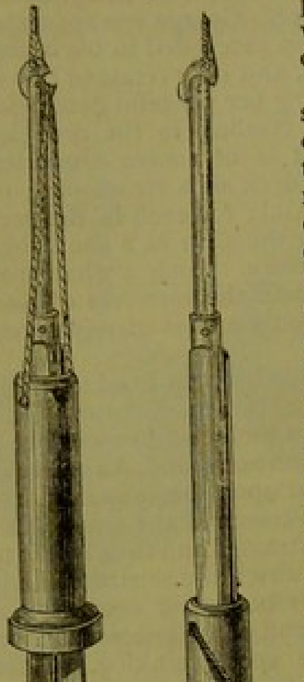


THE HYDRA. BAILEY'S GAUGING ROD.

Another gauging rod, and one more generally used, is an invention of Commodore Bailey's, and resembles the hydra in being a hollow rod with iron weights. But in this instrument the diameter is three inches and the length forty-eight inches, so that it is able to bring to the surface more extensive samples of the ground. Also, the apparatus by which the weights are removed is more efficacious and trustworthy. These instruments, however, are only used when the depth is estimated at more than 1,500 fathoms; for shallower soundings a cylindrical plummet is used, with a hollow receptacle three inches wide and butterfly valves at the lower end, to enclose samples of the ground.

The line used for soundings is manufactured expressly for the purpose. It measures an inch in circumference, and can bear a strain of 14 cwt. It is marked every twenty-five fathoms, and wound on rollers which contain three thousand fathoms. It is kept in a convenient place near the steam winder, over which it is passed and carried through the block to be fastened to the main-yard; the end of it is then attached to the gauging rod.

To obtain samples of the water, a so-called water bottle was sent down with the sounding line. This bottle consisted of a metal cylinder, having a stopcock at each end. The levers by which these stopcocks are moved are connected by a brass rod, so that they are both open or shut exactly at the same moment. When the sounding is to be made, the stopcocks are opened, and the instrument sent down into the water, no check being made in the descent. On the rod which connects the two stopcocks is a metal plate, kept in a vertical position by the water on each side of it; when a contrary motion begins, this plate falls in a horizontal position, and presses on the rod in such a way as to close the stopcocks and enclose the water within the cylinder.



WATER BOTTLES.

The thermometers used in the deep sea soundings are also specially constructed for that purpose, and have retained the name of their inventor and maker, Miller-Casella. They are self-registering, maximum and minimum instruments, and are capable of resisting the pressure of the water even at great depths. At one end of the column is a small quantity of creosote, which marks the expansion or contraction of the temperature; it does this by its effect upon the mercury in the column, which rises and falls as the creosote contracts or expands. Above the quicksilver is a little index of metal, to which a hair spring is fastened; the latter presses against the glass column, and serves to keep the index in its place, so that it can be read off. Of course it is necessary to protect the whole instrument from the pressure of the air and water, and to effect this it is encased in a glass cover, the space between being filled up with spirits of wine, and hermetically sealed, so that the pressure falls only on the outer case, and the inner is influenced by the temperature alone. These thermometers are subject to a hydraulic pressure of from two to three tons on every square inch, and are then pronounced capable of registering at a depth of three thousand fathoms.

When it is intended to begin sounding operations, the rod, with its weights carefully attached, the water bottle, and the thermometer, are fastened to the rope, and the latter is unwound from the machine to the depth of five hundred fathoms; after reaching this depth it is allowed to run out alone. While this is taking place, the interval of time between every marking of a hundred fathoms is accurately noted, and written down in a volume kept at hand for the purpose. These intervals increase in duration as the rope descends, because the weights have to meet the resistance offered to the passage of the rope by the water, and this resistance of course increases with the amount of rope descending. However, the intervals are regular enough to make it certain that if four minutes elapse after the last marking, either the bottom has been reached, or the rope has run out to its full extent. When the intervals have shown that the lead has reached the bottom of the sea, the rope is placed over the steam winder, and carefully drawn up, very slowly at first, and more quickly in proportion as it nears the surface.

When at length the rod, water bottle, and thermometer are safely arrived on board, the latter is at once read off, and its indications written down in the book; the water is then carried into the laboratory, in order that its specific density may be ascertained; and lastly the contents of the rod are examined, to learn what they have to tell of the living creatures below the waves, and the nature of the ocean's bed. The spoils so won are dried and preserved in bottles.

When the rope has been replaced, the next thing is to measure the temperature of the water from the surface to the bottom of the sea, and this is done by fastening thermometers at intervals along the rope. A lead is attached to the end of the rope to keep it in a vertical position, and a thermometer is placed just above the lead; the line is then run out to the depth of a hundred fathoms, when another thermometer is placed on the rope, and so on until from six to eight thermometers have been used, and the rope has gone down to the desired depth, say fifteen hundred fathoms. Then it is allowed to rest for a few minutes, to give the thermometers time to register the temperatures of the different depths. The rope is now drawn up, and every thermometer is taken off as soon as it reaches the surface, in order to have its markings read and written down. Sometimes the temperature is measured from the surface to a depth of seven hundred fathoms, and occasionally it is found necessary to take the temperature every ten fathoms from the surface to a depth of two hundred fathoms, or every fifty fathoms to a depth of six or seven hundred. These latter experiments naturally take up considerably more time.

Almost at the same time as the *Challenger*, the steamship *Tuscarora*, under Captain Belknap, took soundings in the North Pacific Ocean, and the German war corvette *Gazelle*.

under Captain von Schleinitz, sailed to convey the members of the astronomical expedition to Herquelen Island, to observe the transit of Venus. After this had been done, the corvette sailed through the Indian Ocean, rounded New Guinea and Australia, then turned towards Magalhaen's Straits, and returned home, after an absence of nearly two years. During the whole voyage, deep soundings were taken, under the immediate superintendence of Captain von Schleinitz, and aided by the best instruments, and valuable results were obtained.

It is significant to observe that the track of the *Tuscarora* frequently crossed that of the *Challenger* and the *Gazelle*, so that the soundings taken by the three vessels form a good test of the accuracy with which they were conducted.

Among earlier efforts in sounding we must mention the voyage of Captain Denham, between Tristan d'Acunha and the mouth of the River Plate, 37° south latitude, and 37° west longitude from Greenwich. He found, on the 30th of October, 1851, when in that place, that the depth of the Atlantic Ocean was 15,411 yards, but the rope broke on being hauled up. Near to the same place Lieutenant Parker gave the depth as 16,613 yards, but these measurements are by no means to be trusted. The greatest known depth of the sea does not exceed 9,309 yards, and that is found at a certain place in the Pacific Ocean, 44° 53′ north latitude, and 150° 26′ east longitude from Greenwich; this sounding was taken by the *Tuscarora*. The *Challenger* also found great depths in the western part of this ocean, and it is agreed that we must look upon the Pacific as the deepest of the oceans.

It is evident, then, that the greatest depth of the sea does not approach the greatest height of our mountain ranges; for instance, Mount Everest, in the Himalaya range, is 29,000 feet above the level of the sea. The greatest depth found in the Indian Ocean was sounded by the *Gazelle*, 1875, in 16° 11′ south latitude, 117° 32′ east longitude. The *Challenger* found the greatest depth of the Atlantic, north of the Virginian Islands, and gives it as 7,743 yards (23,229 feet). The thermometer enclosed in its iron case could not support the pressure of the water, and came up crushed. This pressure, which weighs down the lower strata of the sea, is equal, at the depth of 4,372 yards, to nearly four atmospheres, and is the principal reason why we shall always find it impossible to explore the abysses of the ocean by means of any diving apparatus. Not that these lower depths are destitute of organic life; on the contrary, they abound in countless varieties of living organisms, all marvellously fitted for the physical circumstances which surround them.

Even the higher forms of marine animals seem able, occasionally, to descend to these depths without harm. It is said that harpooned whales have been known to rush down through the water with such frantic speed that they dash with their heads against the bottom, and break their jawbones. Without vouching for the accuracy of this statement, we may notice that Captain Scoresby, who is generally to be relied upon, states that he once saw a harpooned whale rush down towards the depths with such rapidity that it dragged down the rope and the boat in its descent, and the pressure was so great that the boat immediately filled and went down like a stone; and afterwards, when the dead whale rose to the surface, it was in its turn nearly submerged by the boat.

An opinion used to prevail with reference to the configuration of the ocean beds, that they could boast their mountain chains and precipitous descents, their hills and valleys, equal in height and depth to those of the upper world. Some support was given to this theory by the presence of isolated rocky islands, which rise above the surface of the sea, and present the appearance of summits belonging to high mountains, which we should recognize if the sea were to suddenly disappear. But when the bed of the

Atlantic had been more closely explored, it was found that no such great irregularities of form existed. The contrary theory was then put forward, and the bed of the sea was pronounced to be destitute of any mountain ranges, and nothing but a level plain. The truth, however, lies between the two opinions. There are great ocean beds where the ground is perfectly level, and there are others which have steep descents; there are submarine mountain ranges, submarine valleys, and cavernous recesses. But even among these mountain ranges we must not expect to find the jagged peaks and sharp outlines of our Alps; the power of the surrounding water has made itself felt, and has given to the steepest descents a certain roundness of curve and outline.

The levellings which were made with a view to laying down the Atlantic cable between Ireland and Newfoundland show that the ocean presents between those countries a flat surface of about 350 miles. The inequalities are so slight, that not only are there no steep descents, but the curves are shallow enough to admit of a railway being laid down with very little trouble. This submarine plain does not, however, begin close to the European coast, but on the other side of the steep declivity, of which we have spoken before. This declivity points out the true boundaries of our continent towards the ocean, and there is no other of the great divisions of the world which is surrounded by such a high submarine plateau as that which projects from Europe westward.

The centre of the Atlantic Ocean rolls over a high plain, from about 2,186 to 4,372 yards below the surface of the water. This plain, strangely enough, repeats the S-shaped formation of the ocean itself, and upon it are found the volcanic islands of the Azores, the island of Ascension, and the equally volcanic St. Paul islands,—proof enough that the subterranean forces of imprisoned fire have been at work in that locality.

In the north a system of submarine terraces join Europe to Greenland, and it is not improbable, for many reasons, that in an early period of the earth's development there was a connection by land between Europe and North America. We must not, however, lose sight of the fact, which cannot be too often insisted upon, that on the whole the bed of the ocean is the same at the present moment as it was in primeval ages; that, if we may so express it, the ground plan of the Atlantic was traced even in the world's earliest epochs. All the upliftings and depressions of continents, even during the course of long periods of time, have not been able to efface the general outlines of the configuration of the ocean bed.

The first deep soundings taken in the Atlantic showed that the bottom was covered over a vast extent with a fine slimy mud, which was found to be entirely composed of a species of foraminifera, the *globigerina bulloides.* Besides these only few other foraminifera, a few diatomaceous specimens, and some mineral fragments, were found. This coating of globigerina mud excited much interest, and it was at first supposed that it covered all the bed of the Atlantic. The *Challenger* expedition, however, proved that this idea was erroneous. In the very deep regions near Cape Verde and the Canaries these foraminifera are altogether, or almost altogether, wanting, and the ground consists of red clay. This clay is so finely wrought, that when it is stirred up in water it will remain for days without sinking to the bottom of the glass, giving a chocolate colour to the water. When chemically analysed, it was found to contain an almost pure clay, silica, oxide of iron, and a small quantity of manganese. A substance afterward obtained proved to be superoxide of manganese. This red clay extended straight across the Atlantic to the West Indies, and it is remarkable that in some instances it was found above the globigerina mud, although the latter was seldom found together with the clay. Small particles of lava, pumice-stone, and superoxide of manganese were found within it. Opinions as to its origin are greatly at variance, but it is probable that it is of inorganic origin. The volcanic remains which are found at the bottom of the sea must be ascribed to the effect of submarine eruptions. Only a very insignificant part of them can have reached their present position from the continents of the earth. This is self-evident when we reflect that at the bottom of the sea an absence of movement prevails far more complete than that of any river beds. How then should these great masses of rock be propelled along its quiet depths? Another reason for denying that the volcanic rocks have ever formed part of the earth's surface is that all the *débris* of the continents are found within a very narrow distance from the coast. It is only the fine mud and earth which remains suspended in the water for a length of time, and gives its characteristic colour to the various tracts of the sea's surface, which is carried far out into the centre of the sea, where it slowly sinks at last to rest upon the ocean bed. Dana showed that the fragments torn from the coast never travel far, but are thrown back again by the waves on to the shore.

We may conclude then that the material of which a continent is built remains within its boundaries, and that no stone or rock belonging to Europe has ever helped to form America, or *vice versâ*. For the ocean, like a neutral power, holds asunder the great masses of the land, receiving nearly all that escapes from them within itself, and not letting it go.

But if the fragments of rock and stone are found in narrow limits, close outside the coast line, the mud at the bottom of the sea has probably travelled thither from the very heart of the continents. Particles that are now resting immovable, fathoms deep below the surface of the Atlantic, may in ages past have defied the storm from the wind-smitten summit of the Andes; but the fragment of lava by their side is resting not far from its birth-place.

The Pacific Ocean shows, in the construction of its depths, a very different formation from that of the Atlantic. If we could put a girdle round the earth from the coast of Chili towards the islands of Japan, it would divide the ocean into two very opposite halves. The north-eastern half would have the appearance of a watery waste of great depth, almost destitute of islands; while the south-western is thickly bestrewn with islands, most of which rest upon a common plateau which is at the most only 2,187 yards below the surface, and extends over more than 3,850,000 square miles. This submarine plateau shows in its torn and jagged surface all the peculiarities of the continental mountainous districts. The softly curved swells of the North Atlantic Ocean, which were too hastily accepted as the type of the configuration of the ocean bed, are here replaced by steep descents and extensive submarine mountain chains, whose highest peaks appear above the surface in a long range of heights. The Hawaii Islands are nothing but the highest peaks of a far-stretching mountain range, which surpass in length, and perhaps even in mass, the Himalayan ranges. If the waters of the Pacific were to disappear, this mountain chain would stand out in all its magnificence, and project farther above the bottom of the sea, than the giants of the Himalayas tower above the deep plain of the Ganges.

The level plain of the bed of the north-eastern part of the ocean is covered with a yellowish brown mud, but fragments of lava, and of coral reefs, are found on the submarine heights which extend from the Hawaii Islands towards the Japanese coast. The greatest ocean depths which are known at this day are found to the north of this line, parallel to the coast of Japan and the Kurile Islands. The existence of this deep ocean abyss is now proved beyond all doubt, and extends more than four and a half miles; for it was here that soundings were made with the greatest success. The piano wire, used on the American ship *Tuscarora*, ran straight to its aim, and the contact with the bottom of the sea was as accurately noted at a depth of 27,125 feet as in the shallowest districts. It is probable that the above-named depth is by no means the greatest, but there was unfortunately no more wire on board the *Tuscarora* to continue the experiments.

The western part of the Pacific Ocean, between Australia and the China Sea, possesses a very marked formation of bed; submarine elevations form here as it were separating dams, and in the submarine plateau are found immense cavities, to the depth of 4,332 yards; similar depressions within the bed of the sea are found to the east and north-east of Australia. The Indian Ocean is deepest between Sumatra and Australia; south of forty degrees latitude the depth decreases considerably, and the volcanic islands of St. Paul and New Amsterdam are situated upon a submarine plateau.

The submarine terraces along the coast of Africa extend eastward beyond Madagascar, and upon them are found Amirante, the Seychelles, and the Mascarene Islands, while on the Indian coast the Laccadive and Maldive groups rest upon a subterranean bank which extends beyond the equator.

Although the organic life of the island of Madagascar has by no means been exhaustively studied, we nevertheless have learnt enough of it to be able to look upon the island as a little world of itself; thanks to its wealth of individual species, both of the animal and vegetable kingdom.

Ceylon, as might have been expected from its close proximity to the mainland, exhibits a great similarity in its forms of animal life to those of the Indian peninsula. On the other hand, Carl Ritter, and more distinctly still Sir Emerson Tennant, have declared that Ceylon is not to be looked upon as a fragment torn from the Deccan: the latter writer, especially in his work upon the animal and vegetable productions of Ceylon, declares that the island has preserved even to the present day a distinct individuality of production; a fact the more to be noted because the beginning of a connection with the mainland by means of Adam's bridge would appear to exist, a bridge which, according to Indian tradition, the allied monkey-kings built for the Rama, on his invasion of the island.

We have, then, in Madagascar and Ceylon the remains of the old-world islands which were not connected with the mainland, but were most probably joined one to the other, and situated above the Seychelles, granite islands to the north, and in a direct line with Madagascar. Every believer in the unity of our earth's creation is forced to admit that in the remote tertiary period a vast continent extended over Madagascar, Rodriguez, the Seychelles, the Maldives, and Ceylon; probably, indeed, comprising the Celebes within its limits; for the lemurs, or fox-apes, and various species of monkeys allied to them, are confined to these islands, and that is why Sclater has given to the whole district the name of Lemuria. The Celebes show, by the few varieties of mammalia which they possess, that it must have been at some remote period joined to the western continent.

Perhaps also the lands of the Cape belong to the Ethiopian continent of the primeval world; for they distinguish themselves by such separate and even contrasting forms of animal and vegetable life, that the great naturalist, Dr. Hooker, pronounces them to be the remains of a former continent which has been incorporated into Africa, as the latter continent extended downward.

Another evidence that the distribution of land and water in the district of the Indian Ocean must at one time have been very different from what it is now, is that the fossil remains of plants at the island of Kerguelen prove the former existence of vast forests upon its surface, while at the present day only a few lower forms of vegetable life struggle for a doubtful existence.

We know but little of the depth of the southern Arctic Ocean, but, according to the soundings taken by Sir James Ross in 1840—1843, no very considerable depths are found within its extent. The northern Arctic seas are better known to us. We have already stated that they are separated from the Atlantic depths by a submarine plateau rising to within 2,045 yards from the surface, and finding a natural boundary at Behring's Straits. From this circumstance, and from its being so shut in by the land, the Arctic Ocean has almost the character of an inland sea. The greatest depth between Greenland and Spitzbergen is almost 5,116 yards, while the district between Nova Zembla and Spitzbergen is comparatively shallow.

The recent deep sea soundings have led to conclusions of universal interest and importance. Dr. von Boguslawski has examined the subject critically, and comments upon it as follows :—" It was formerly supposed that the greatest depths of the ocean were to be sought for at a distance from the coast, and in the centre of the open seas; but according to the results of the latest deep soundings this is not the case. For instance, the greatest depth in the North Pacific Ocean was found near the western shore, that is, in the neighbourhood of the continent of Asia. The Atlantic also shows the remarkable fact that its greatest depths are found near to the islands or the mainland along the western coast. In the Indian Ocean the deepest soundings were taken on the eastern side and near the Australian continent; but as far as our present knowledge extends, the South Pacific is the only ocean in which the deepest soundings are found in the centre.

" It must be remembered that the bottom of the sea *immediately* adjoining the mainland must be looked upon as a mere prolongation of the continent or island; and the distance between the land and the beginning of what is really the bed of the ocean differs considerably with different circumstances; being very slightly distant from the land on steep coasts, and much farther removed on flat sandy shores. The latter extend in gentle undulations, far out into the sea, and the ground sinks by imperceptible degrees to the real oceanic basin. Mainlands and islands are often connected by flat shallow stretches of sea, or by submarine plateaux, and so form together a common tract of elevation measured from the centre of the globe as the starting point; and separated by the great depression of the ocean beds, which are measured with reference to the same centre. Quite different is the case with the steep coast which sinks down sheer into the sea, and where at a very slight distance from the land depths are found belonging to the true ocean bed."

We often see in geographical works sectioned charts of the ocean, in which the depths below the surface, and heights rising above it, are represented by a curved line. Nothing, however, can be more untrustworthy than these representations. The points and sharp outlines by which the islands are denoted do not exist in fact, and give a most misleading impression of the reality. Of course this false proportion of the drawing is absolutely unavoidable, as it is impossible to procure any paper the length of which can be in proportion to the depth required to be indicated.

By far the best idea that we can gain of the bed of the ocean is that given us by the examination of tracts of land which have risen above the ocean at comparatively recent periods. Splendid examples of the gradual and regular depressions of the bottom of the sea can be studied in the French *Landes*, low-lying plains which once filled the Bay of Poitou; a great part of the desert of Sahara, and the South American Pampas in the states of La Plata. Even such steep and rocky coasts as those of Scotland or Norway have been smoothed down and levelled here and there in the shallower parts which have not long ago risen above the surface of the Atlantic.

If it were not for the recurrence of earthquakes, volcanoes, and the slower processes of elevation and depression, the incessant alluvial deposits, the breaking up and crumbling of rocks through the action of the waves, and above all the unwearied work of the minute living organisms of the sea itself, would before long smooth away every inequality of the ocean bed, and the consequence would be a gradual advance of the waters over the earth's surface, so that after some thousands of years the globe would become again what it was originally, an oblate spheroid, surrounded on all sides by water.

Temperature of the Ocean.

When we investigate the depths of the sea, we find that every increase of depth is accompanied by a decrease of temperature. It is always necessary, therefore, to distinguish between the temperature at the surface and at great depths below. If we examine the ocean abysses, we shall find that the temperature is very low, but that even at the greatest known depths it does not descend to freezing point. It was formerly impossible to obtain an accurate idea of the average depth of the ocean, because of the overwhelming pressure of the water. Either the thermometers were drawn up broken to pieces, or the results, thanks to the pressure exercised up the frame, were very untrustworthy.

The Miller-Casella thermometer, of which we have spoken before, enables us now to take accurate temperatures, but the process is still very difficult and delicate, because, although we can ascertain the lowest temperature, we can neither tell at what depth this temperature was registered, nor how the varying watery strata of heat and cold are distributed. We have therefore no resource but to lower the thermometer by degrees, reading off the results every time; or to fasten several thermometers at intervals along the rope. This method is called taking serial temperatures, and it is clear that it must be, if not exactly a difficult, yet a most delicate process.

While fresh water attains its greatest weight and density at a temperature of + 38° Fahr., salt water contracts down to freezing point, and therefore, as it becomes colder in proportion as it is heavier, the coldest water is always found in the lowest strata.

Later investigations show that the freezing point of sea water is about 3° below the freezing point of distilled water. It was the famous traveller Péron who was the first to put forward, as the result of his experiments, the statement of the sea's coldness increasing with its depth, but he was led on to the conclusion that in the lower depths of the ocean we should find a region of eternal ice, answering to that of our high mountain peaks. This conclusion, however, was never accepted, and soon afterwards Lenz, as the result of more exact investigations, was able to show that, although a region of fixed temperature prevailed in the lower strata of the ocean, yet that the depth at which this unchangeable temperature was found is very unequal, varying according to its geographical latitude, and therefore being greatest at the equator and least at the poles. In the Arctic seas the temperature at various depths was found to be from 1° to 3° below the freezing point of distilled water; as was proved by Scoresby and Sabine in Baffin's Bay, at a depth of from 4,060 to 6,090 feet. In the seas near Greenland, between 15° east long. and 15° west long. (Greenwich), and in the 75th parallel north lat., Scoresby found that there was no decrease of warmth, although the depth was greater; and between 2,030 and 4,060 feet below the surface the temperature of the water stood at from 35° to 36° Fahr. Captain Ross fully established this singular fact.

The information gained from modern research upon this subject of the varying temperature of the sea is now extensive and trustworthy, although so short a time has elapsed since it was possible to be gained satisfactorily. It may be summed up as follows:—

1. The temperature of sea water generally decreases from the surface to the bottom of the sea; quickly at first, and then more slowly, until a depth of about 797 to 1,202 yards, where an average temperature of + 36° Fahr. prevails; and then there is a still more gradual decrease to the bed of the ocean, where not only in the temperate zones, but in the tropics, the lowest depths have a temperature of from zero to 34° Fahr. and in the Arctic Oceans of 2° to 5° below freezing point.

2. The temperature of those parts of the sea which have free connection with the Arctic Oceans is lower than that which they would have possessed according to the average winter temperature of their surface, and is indeed very little higher than the ocean bed of the Arctic seas themselves.

3. The general depression of temperature found to exist at the bottom and in the lower depths of the sea must not be ascribed to the cold polar surface currents, which are comparatively of small importance, and merely flow from the poles towards the equator to make up for the mass of water which forces its way up from the low latitudes, but rather to a slow but powerful advance of the collective mass of the lower ocean strata from the poles towards the equator, the upward force of which from the bottom of the sea amounts to about 4,001 yards, and by which the cold ground water in low latitudes and at the equator itself finds its way nearly to the surface.

4. The temperature of the ocean's depths is lower in proportion as the communication between the particular spot and the Arctic seas is open and extensive. Upon the whole, therefore, the temperature of places upon a given latitude in the Pacific and Indian Oceans is lower than upon the same latitude in the Atlantic, because the communication between the former seas with the Antarctic Ocean is more open than in the case of the Atlantic; and for the same reason the southern districts of the sea are colder, because the communication with the northern Polar ocean is much less free than with the Antarctic, and indeed in the Indian Ocean does not exist at all.

5. The temperature of the water at the bottom of the Arctic seas is from 2° to 3° below freezing point; a little above it rises from freezing point to 5° Fahr.; in the central latitudes, at the depth of 4,001 to 6,003 yards, it is from 33° to 34°; and at the equator a little above freezing point, but in some places below. The temperature of the surface of the sea in districts lying between the equator and 45° N. lat. is rather higher than that of the air immediately above it, but the difference is very slight, and subject to unimportant variations. In 1,371 out of 1,850 observations taken by Captain Duperrey in the tropics, the sea was found to be warmer than the air. Humboldt estimates the highest average temperature of the sea at about 60°, between 8° and 9° N. lat. The highest temperature is by no means found at the equator itself, but at about 6° N. lat. The variations of the sea's temperature are very slight; it is warmest from two to three o'clock in the afternoon, and coldest about sunrise; but the difference is only about 2°, and the variation caused by the changing seasons of the year is only perceptible in higher latitudes. The warmth of the water of the Atlantic in 50° N. lat. varies in the course of the year between 42° and 45°.

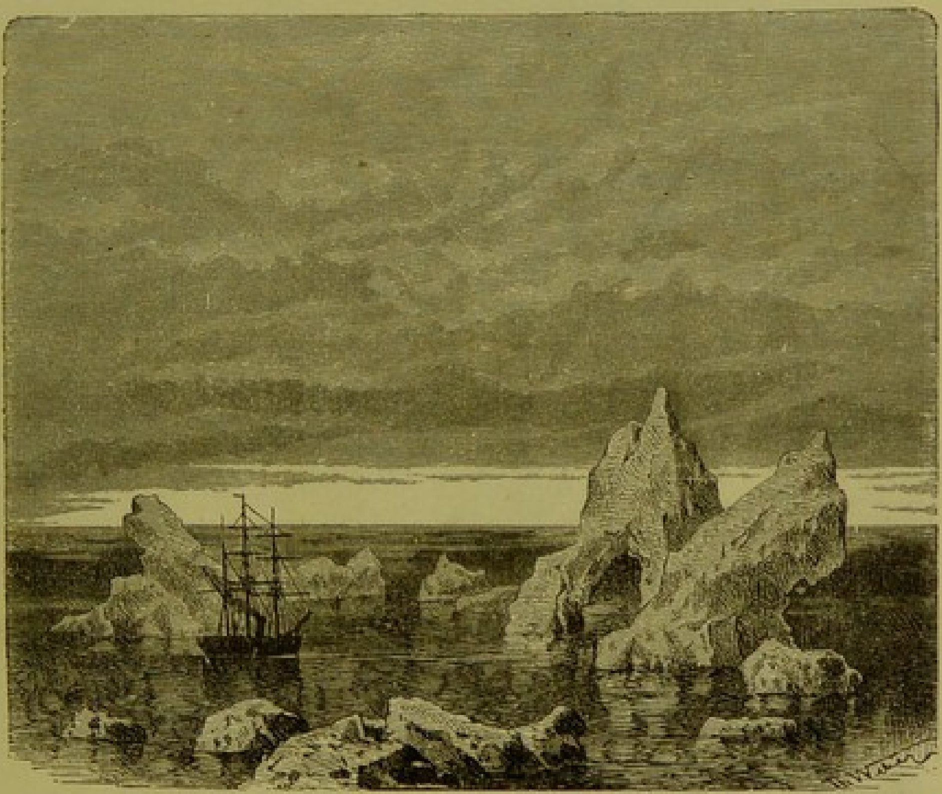
In small inland seas and near the coast, this evenness of temperature which characterises the open seas is far less marked, in consequence of the currents of air produced by the mainland, which is more quickly warmed than the water. These air currents depend upon the temperature of the land, and change with its changes; therefore the seas inclosed by the land show in summer a higher temperature than the open ocean in the same latitude, as was shown more than a century and a half ago by Marsigli in his observations of the temperature of the Mediterranean Sea, and more decidedly still by Gautier's experiments. Humboldt found on the 24th of August, 1834, that the temperature of the waters of the Baltic, near Swinemunde, was about 55°, or almost equal to that of the open ocean in the tropics. While upon the mainland January is usually found to be the coldest month of the year, the temperature of the sea is lowest toward the end of February and in March. The reason of this difference is that the water, which receives heat more slowly than the land, has to remain for a longer time exposed to the influence of the sun's ray before the temperature perceptibly rises. And in the same way the sea holds the heat longer than the land does, and therefore, while the greatest heat on land is generally in the month of July, the sea is warmest at the end of August and the beginning of September.

Mass of Ice in the Arctic Regions.

It is a curious fact that the temperature of the sea sinks over shallows and reefs. The celebrated Benjamin Franklin seems to have been the first who pointed this out, and at the same time Jonathan Williams called the attention of sailors to the fact that the thermometer was a never-failing danger signal of the presence of sunken rocks. Humboldt, sailing over a sandbank between Tobago and the coast of Granada, saw the mercury fall from about 38° to 35°. The cause of this is probably to be found in the cold currents which flow round the cliffs. In such cases the coldness of the water is often visibly apparent by the slight fog or vapour which gathers at a little height above these places. Along the coast, or in other places where the sea is shallow, this depression of temperature is not found, because there is not the cold water of the lower depths beneath, and in some cases because the sun's rays can reach the bottom, and warm it as they do the land.

The Ice of the Seas.

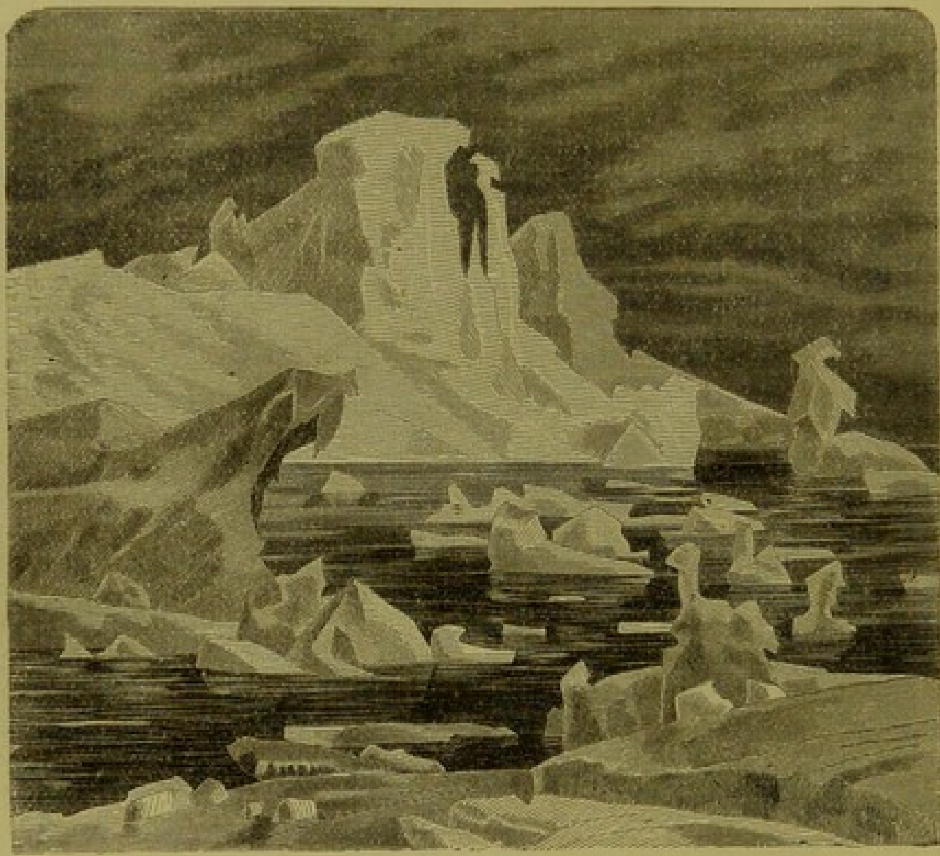
The district of the ocean near the North Pole shows upon the grandest scale the formation of vast ice masses, and is sometimes characteristically termed the icy or frozen seas. Upon our maps we see the northern and southern Arctic Oceans, each bounded by its respective *arctic circle*. In reality there exists of course no sharp boundary line, and if by frozen sea is meant all the waters in which great masses of ice abound, we find that these waters vary considerably in extent at different times, and that the north Arctic Ocean is essentially different from the Antarctic. And, strange as it may appear at the first glance, it is in winter that this frozen ocean is confined within its narrowest limits. The truth is that in the winter the Arctic Ocean collects its icy currents, and gathers them up into their wintry sleep: the very storm and dash of the waves in these far northern regions are hushed, and all seems bound in death-like fetters. Not until the process of thawing sets in do the icy masses awake to the call of wind and the force



Ice Blink.

of currents, and, following their motive power, move slowly towards warmer climates. In the antarctic hemisphere these masses of ice are found much nearer the equator than in the northern seas. It was on one of these icebergs that the *Guardian* broke up and was lost in the year 1870, 44° 10′ S. lat., and 44° 35′ E. long.; and nearer our own day many an Australian emigrant ship has perished south of the coast. In the year 1828, drift ice was encountered even in S. lat. 35°, and 18° E. long.; that is, the parallel of Cape Town, which in north latitude is the same as the Azores.

The reason that the antarctic waters are able to send their masses of ice so much nearer the equator is that the southern hemisphere is so much colder and moister than the northern; but it is chiefly due to the warm currents that our hemisphere is protected against the invasion of these frozen masses. For in the Atlantic Ocean the Gulf Stream forms a sheltering rampart, before which these giants of the icy seas melt away powerless; and in the North Pacific the warm current from Japan guards the North American coasts from Vancouver's Island onward, and causes them to be far less desolate than the eastern coasts of the same latitudes. Long before the adventurous seaman finds himself actually face to face with the icebergs, the approach of the ice is indicated to him by a brilliant band of light along the horizon, termed by the sailors *ice blink*. This light proceeds from masses of ice which are perhaps from twenty-two to twenty-seven miles away, but whose pale light is rendered visible by the refraction of the sun's rays. The ice blink generally presents the appearance of broad pale bands, which contrast sharply with the dull grey of the sky. Payer describes it as bluish in colour, and having a distant resemblance to the aurora borealis. The members of the first German arctic expe-



DRIFT ICE.

dition saw the ice blink very distinctly against an unclouded sky overhead, but with a light mist extending over the horizon. Indeed, it is this very mist, illuminated by the rays of light thrown out by the icebergs, that causes the appearance of the ice blink. Now as the water possesses far less power of throwing out the rays of light, the sky over the open sea appears proportionately dark, so that on the ice blink the tracts of water between the masses of ice can be seen for a circle of from twenty to thirty geographical miles against the clouded sky. Each channel of water looks like a black stripe reflected on this pale light, and to the eye of an experienced sailor the heavens themselves become a chart of navigation by which he is able to steer his course. By the position and extent of these dark lines in the sky, he can, from a distance too great for his eye to reach along the ocean, choose out that course which is most likely to be least encumbered with ice, and to offer him the freest passage.

The ice blink is as it were a friendly warning to seamen to avoid the region of terror, and the dangers which haunt the frozen seas; but if, undaunted, he dares to press forward, he soon finds himself surrounded by greater or less masses of drift ice, the pioneers who precede by many a day's march the advance of the regular army. These masses of ice are only of moderate size, and appear in long lines or ranks. They protect the ship from the swell of the sea; but sometimes, on being attacked by violent winds, they are broken up and scattered into many smaller ranks, each of which sails away, so to speak, upon its own account, and being carried down into the open sea, melts away, and is mingled with the waters. "Very often," observes Koldewey, "large fields

THE "TEGETTHAFF" IN THE ICE.

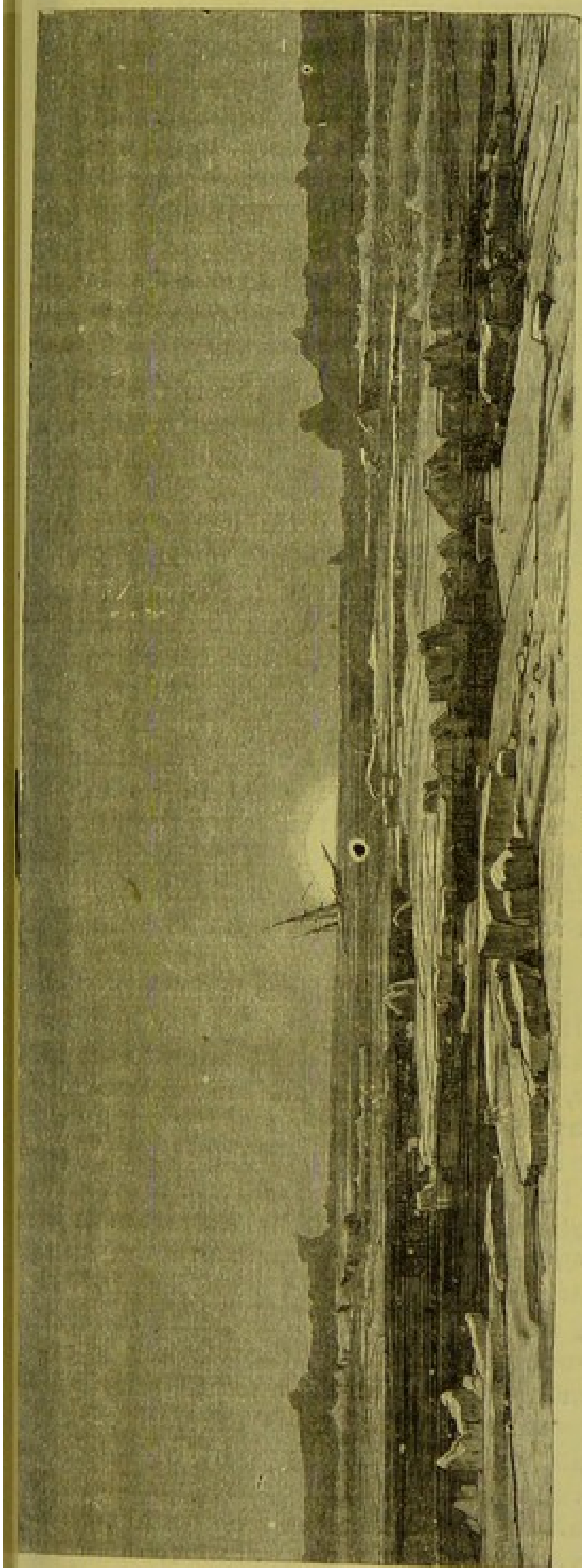
of this split and shattered ice, too vast for the eye to see across them, are met with in these seas, and found to be made up of small pieces of ice of about two or three hundredweight each, and the sea is occasionally so covered by these ice fields, that the ship is unable to find a passage through them." The ice of the Arctic seas must be classed into two very different species, surface ice, or floe ice, and the glacier ice. The former makes the ice field, the latter the ice berg; the former owes its origin to the sea, the latter to the mainland. It has long been a disputed point whether ice could be formed upon the open seas; but the answer has been conclusively given in the affirmative by the observations of Captain Scoresby. By a sufficiently intense degree of cold, the fine snow forms into minute ice crystals, which gradually beat down the waves, and harden into ice flakes of from three to four inches in diameter. The restless play of the billows scarcely ever allows the formation of a large solid covering of ice; and only in very quiet bays, and with a high degree of frost, has the surface been covered in a single night with a crust of ice about three inches thick, and which in time might attain to a thickness of several feet.

It is clear that a level surface must be produced as the first result of freezing, but the actual ice fields very seldom assume such an appearance; on the contrary, they present every kind of inequality of surface, and frequently exhibit the most fantastic forms. The process of transformation by which the level surface takes these extraordinary shapes was diligently studied by the Austro-Hungarian arctic expedition, whose ship *Tegetthoff*, fast bound for a whole year by these icy masses, and drifting with them at their will and pleasure, afforded every opportunity for making observations. Weyprecht, the leader of this expedition, was able to follow closely the gradual conversion of the thin ice into solid ice, and the solitary ice blocks of one year's growth into pack ice or long stretches of closely packed hillocks and small fields of ice. He says :—

"The reason of the destructive process is the constantly recurring cracking of the ice, by which the fields are continually being split and rent in every direction, to be joined again afterwards in new combinations, by the subsequent pressure and the formation of new (*young*) ice. The cracking itself is occasioned by the unceasing drifting and swaying movement of the ice fields themselves, and the consequent mutual pressure to which it gives rise.

"Wind and currents give the first impetus, but besides these forces there are others which contribute to the formation of the rifts. And principally we must seek these forces in the difference of temperature, which is most perceptible in autumn, at the time when the older layers of snow are melted entirely away, and the ice is covered only by a thin stratum of frozen snow, or is left wholly uncovered. As soon as the rapid fall of temperature which accompanies this period sets in, countless small fissures appear, of which the greater part certainly are only superficial, but some extend deep enough for the water to penetrate. These fissures are only local, and are seldom of great extent. They are widest in the centre, and narrow gradually towards the ends, which are lost along the surface; and this formation proves that they are owing to the contraction of the ice itself. When the decrease of temperature sets in with great suddenness, they break out on all sides, so that the air is full of an incessant crackling, splitting and rending, which lasts for hours at a stretch. If the ice is swept clear of the snow in the spring of the year, scarcely a quarter of a yard will be found free from these little cracks. Ice has a difference of temperature extending from freezing point in summer to fifty degrees below in winter. In the latter season, the changes of temperature are extremely sudden; indeed, it sometimes occurs with the sudden rise of southerly winds, or of the north wind which follows them, that the mercury rises or falls forty degrees within twenty-four hours.

"If it were not for the snow lying upon the ice, and protecting it from these rapid changes by being such a bad conductor of heat, the consequences would be still more apparent. In the interior of these ice masses, the difference of temperature between the frozen air without, and the uniform degree of warmth preserved in the sea water, is forced to seek its equilibrium below. Therefore the different kinds and thicknesses of the snow covering, and the different thicknesses of the ice itself, must exercise a constant strain upon the latter; for where the actual ice bed is protected from the changes of the atmospheric temperature by deep drifts of snow or masses of surface ice, the effect produced by the air must be very different from that produced on other tracts of ice, lying perhaps close to the former, but having only the ordinary thickness of the ice bed, and being clear or partly cleared of snow. Moreover, the equilibrium is constantly being disturbed by the differences in the growth of the ice itself. The rapidity with which ice is formed decreases with the thickness of the ice, and as this is by no means always the same, the growth is very unequal. Supposing that a fissure had appeared and been frozen over in ice about six or seven feet in thickness, the young ice at the end of a month would, if the atmospheric temperature was very low, be perhaps rather more than three feet high, while the old ice round it would only have increased in depth by one-tenth of this amount. Now if the young ice did not adhere to the old, it would, by reason of its light weight, be raised in the water about seven inches; while the raising of the old ice, in consequence of its additional growth, would only be seven-tenths of an inch. Every formation of fresh ice must therefore, in accordance with what has been said, lay the foundations of a new disturbance of equilibrium, and be the source of fresh rifts and fissures. And it is not only the formation of young ice, but the unequal growth of the old ice, which produces the same results; for if an ice field consisted of a level surface of uniform thickness, its growth along the whole extent would be equally uni orm. This, however, is not the case; every mound of ice, every snow-drift, and every clearii g, modifies the growth of the water which lies beneath. These causes produce continual variations in the mutual pressure carried on within the ice itself, and constant local disturbances of equilibrium. To these causes we must add the displacement of pressure continually arising by the drifting masses of snow. The ever-recurring storms of the wintry season swoop down upon the new-fallen snow, and drive it up and down, over level and broken ice alike, in masses of the most various proportions.



Ice Fields.

"It is clear then that these endless changes of circumstances must occasion constant straining in the ice bed. It is possible that the elasticity and power of cohesion of the ice itself would scarcely be broken, if other and exterior forces, such as the shock of converging ice fields set in motion and driven swiftly forward by wind and current, did not give the first impulse. By this mutual pressure a rift is formed, extending all across the ice field, which occasions a fresh destruction of the equilibrium of the parts near it until a further rift in a contrary direction makes up for its effects, and restores the balance. This process of disturbance and restoration is continued until the central ice is sufficiently strong to bear the strain and resist influences from without. It is only in this way that we can explain the peculiar formation of some of these crevices which have been observed by explorers to extend for miles along the ice of the largest fields.

"Wrangel, in his description of a sleighing tour northward from the coast of Siberia, mentions the singular heaping of pieces of ice one above the other. They rose on one side in a sloping plain, and reached sometimes to enormous heights, and on the other hand formed a vertical wall. As he was never able to examine the formation and growth of ice, he could not give any satisfactory explanation of the phenomenon; but it is known that these strange forms assumed by the fragments of broken ice are due to nothing else but the local pressure exercised on the broken pieces of some great fissure which have been afterwards drifted and heaped up in a lateral direction. Every split in the ice widens immediately and with great rapidity: the water, rushing in with terrific force, soon drives the sundered fragments far apart. As if rejoicing to be free from the hated fetters which have imposed upon it an involuntary calm, the sea draws a deep breath, and rises and falls with a wide swell; fragments of ice of all sizes, which had been drawn below the surface, rise above it now, announced by the gurgling of the water. With swift current and heavy beat of waves, the ocean is slow to be appeased, and long in finding rest. The wider the cleft opens, the more regular is this billowy motion of the water; and the seaman watching it from a distance fancies that he sees the effect of some ocean channel. The movement continues for a long time; indeed, it seldom ceases until the young ice has attained sufficient thickness to be able to stifle and suppress further agitation from below.

"The sudden appearance of one of these great fissures has a singular effect on the spectator. One can only guess at the force which drives the two hostile powers asunder, and the relentless, perpetual advance of the dividing chasm seems to point to the working of some mysterious unknown cause acting from afar off. The eye accustomed to the vague blurred outlines of the arctic scenery, and the eternal monotony of gleaming white, looks in wonder at this sudden appearance of a coal-black band which contrasts so sharply against the margin of the ice, and which at some little distance is lost in the deep darkness of unbroken night. The traveller rejoices to see again once more something else than ice on every side, nothing but ice, and greets with a welcoming glance the re-appearance of the half-forgotten, friendly seas."

As we have stated before, water in freezing throws out the salt which it contains. This separation of the crystalline sea salt may be observed in a hundred ways within the polar seas. According to Wrangel, who was much interested in the matter which he watched in the frozen seas of Siberia, the sea salt appears on thin stretches of ice, in the form of little heaps scarcely more than half an inch high. Weyprecht has followed and observed the whole process very closely. He says, "When the growth of ice is carried on quickly in times of intense cold, a great number of crystals are formed, whose salt particles are not only drawn downwards in the water, but scattered round on all sides. In consequence of this, the original melted ice consists of crystals loosely adhering together, and mixed with the solution of salt which has been rejected from them all. As the ice grows harder by the freezing together of the separate ice crystals, this solution also freezes with them in its upper strata. When the latter has attained a certain degree of thickness, the further formation of the lower strata progresses only very slowly. The addition of fresh ice crystals from below goes on regularly, but in their formation the salt is almost all carried downwards into the sea, and thus puts an end to the freezing of the rejected salt.

Weyprecht tells us that where the salt lies upon surfaces which are clear of snow, it eats into the ice and makes it brittle. The lapse of a few hours is enough to allow the process of the crystallization of the salt solution to set in. The crystals first spring forth in separate, closely connected clusters, and quickly grow and spread into little piles and heaps. The level surface of the young ice presents the appearance of a field covered with frozen snow, through which here and there the little tufts of grass could be discerned. The delicate icy spears press closer and closer together, and in about twenty-four hours a stratum more than an inch in height lies scattered over the young ice, so that an uninitiated spectator might think it had been snowing. These *spears*, however, do not consist entirely of pure salt; they are, strictly speaking, ice spears covered with salt crystals. The thicker the young ice becomes, the weaker is the influence exercised upon its upper strata by the sea water, which is relatively warmer than the outer air; and consequently the deeper is the fall of the temperature in the frozen solution of salt. As the freezing point of water is lower in proportion to the quantity of salt which it contains, every fall of the temperature brings fresh solutions of salt to be frozen; the ice crystals, however, being always mixed with salt crystals. By this continuous freezing of fresh solutions of salt the fluid residuum comes gradually nearer to that point at which, by reason of its preponderance of salt, it is able to resist the most intense degrees of cold. On the surface there remains a highly concentrated

THE GREAT GEYSER, ICELAND.

solution of salt, which keeps the ice moist for days together, and makes it extremely unyielding. Gradually, however, the salt, partly by evaporation, partly by absorption into the water contained within it, partly by hoarfrost and drifted snow, arrives at complete crystallization, and not until then does the ice become brittle.

If the traveller happens to walk over a field of young ice in the condition we have just described, and before any fresh snow has fallen, he will be astonished to see his footprints marked upon the white plain, as if he were treading upon melted snow, and he will fail to understand how it is possible to find any ice or snow in a state of thaw when the temperature is so far below freezing point. But the moisture in which the traces of his steps are visible is not water, but a highly concentrated solution of salt, which is slowly

GLACIER ICE.

absorbed in course of time. Returning for a while to the contemplation of the ice fields themselves, we find them frequently to be of the most astonishing dimensions. It is no rarity to meet with ice fields many miles in extent; nay, some have been found upon whose surface a small German principality could find room to extend its frontiers. We gather from Captain Scoresby's narrative, that there is nothing more majestic and terrible than the conflicting crash of two such ice fields rushing towards each other as he frequently saw them do at the rate of several kilometres (several thousand yards) an hour. The sudden forced arrest of such gigantic masses, possessing, as is often the case, a weight of many million tons, produces a mechanical convulsion which transcends all description. Scoresby justly declares that the strongest ship would be as powerless to resist the collision of two ice fields as a sheet of paper would be to arrest the flight of a cannon ball.

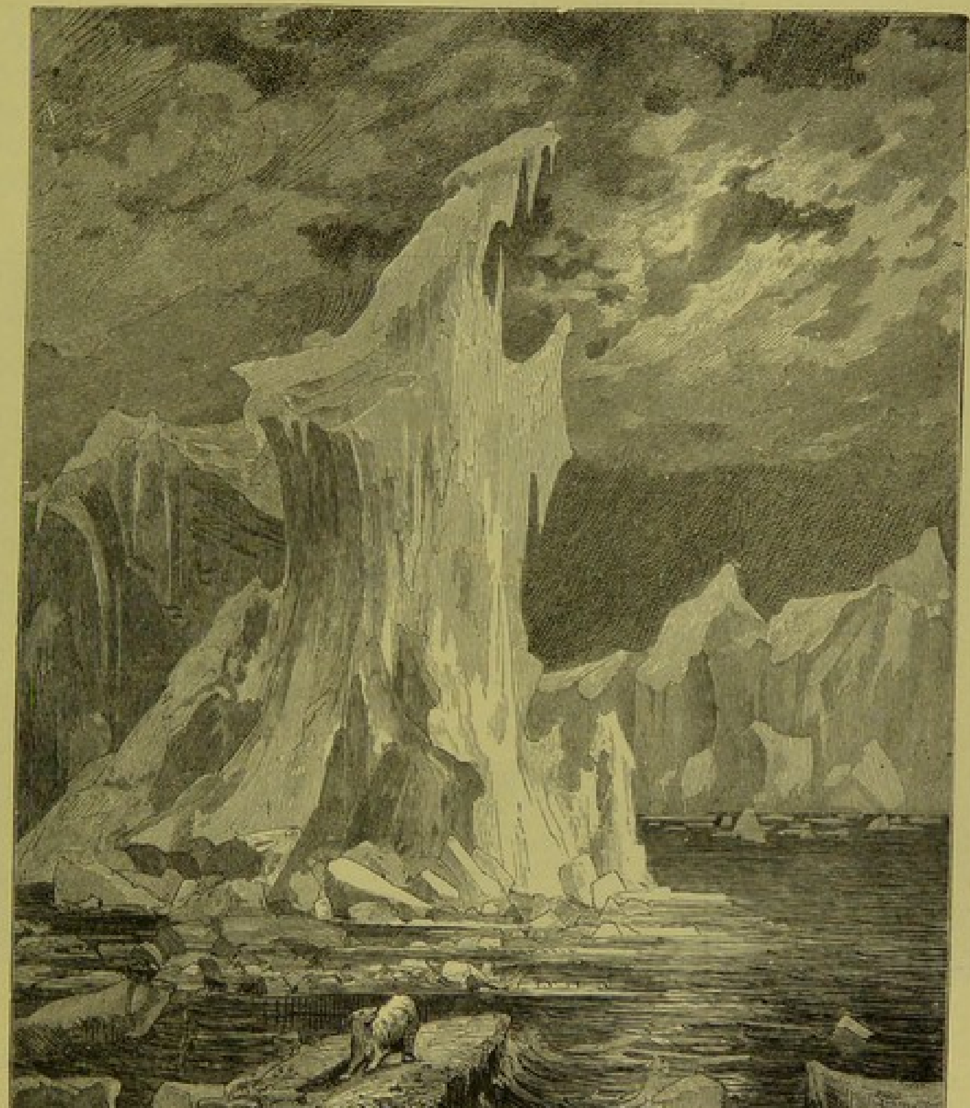
Icebergs owe their origin to the glaciers of the Arctic island world. Where, as in Greenland, Spitzbergen, and San Josef's land, the glacier ice in its slow advance is driven out into the sea, it is forced at last to break up into immense fragments, in consequence of the configuration of the bed of the sea and the different specific gravities of ice and water. These fragments, abandoned to the waves, and drifting idly hither and thither at the will of winds and currents, are the familiar icebergs, fraught with danger to the adventurous sailor who dares to brave the gloom of the Arctic seas. Weyprecht's researches have thrown much valuable light upon the processes which have to do with their formation, and we must follow him here in his exposition of the several details. The only reason, he says, which explains the breaking up of the glaciers into icebergs, is the difference of weight between the ice and the water which is dislodged by it. As long as the former exceeds the latter, the glacier glides onward along the bottom of the sea, sinking deeper and deeper, until the equilibrium is found. But from this point the ice begins to grow lighter than the water which it has dislodged, and suffers a pressure from above, which increases with its further advance, until it has attained sufficient power to overcome the power of cohesion existing within the ice. On coasts where the descent is unusually precipitous, however, it is quite possible for the opposite state of things to exist, and the fragments of ice to be broken off simply by their own weight, before the whole mass has had time to sink deep enough to find its weight in equilibrium with that of the water it displaces; but this latter case can only exist where the descent from the glacier bed is very swift and sudden. The former is the normal manner in which icebergs are created.

When the glacier, on reaching the shore, has freed itself from the bed in which it was confined, it spreads out, and rapidly finds its level. If it then sinks into a very shallow sea, or a bay where the coast is flat, and runs far out in a gradual descent, its progress will be proportionately slow, and the icebergs which it casts off will be comparatively small and insignificant. This is found to be the case along the southern coast of Spitzbergen and the whole western and northern coast line of Nova Zembla. The formation of glaciers is as fully developed here as in any other Arctic district; and every valley with only a moderate rise of mountainous land behind it sends its glacier to the sea. But none of these glaciers throw off any icebergs in the true sense of the word; their contributions to the waters are merely blocks of ice or fragments of icebergs, with no high, sharply cut outlines. And where, by reason of the ocean currents, the warm air, and the open sea, much warmth is carried toward the coast, as, for instance, on the western coast of Nova Zembla, 75° N. latitude, the glaciers, unless they are of unusual size, no longer furnish their contingent of these ice blocks. In this case the glacier is diminished partly by melting away, partly by the crumbling off of small fragments which lie stranded in shallow water, and partly by the warm currents of air and water which gradually cause it to break up and dissolve, and finally carry it away seaward.

It follows, then, from what we have just said, that the great icebergs must not be looked for where the coast is shallow, unless the height and formation of the mountain land at the back is such that they are thrust out to a great distance from the land. The origin of those giant icebergs which are sometimes many miles in circumference, while they rise above the sea to a height of 205 feet, and sink below it to a depth of 1,015 feet—veritable floating and drifting islands—must be sought for in the Arctic mountain regions washed by the deep waters of the icy seas.

The largest icebergs of the Arctic Ocean, therefore, are found in Davis

Straits. These colossal masses are sometimes more than two miles long, three-quarters of a mile broad, 100 feet high, and of more than 410 feet draught. Laden with stones and masses of *débris,* they float southwards, gradually worn away by the warm rays of the sun, and as they near the coast of Newfoundland, after their voyage of more than 2,000 geographical miles, they melt away, and let fall their heavy load of stony rubbish to the



ICEBERGS.

bottom of the sea. It is in this way that the mountains which drift away from Greenland are being built up again on the bed of the ocean far to the south of their former home; and after the lapse of myriads of years, if the process still continues without interruption, a new continent will rise from the depth of the seas, formed of those elements which once towered aloft in the icy arctic night as mountain peaks near the North Pole.

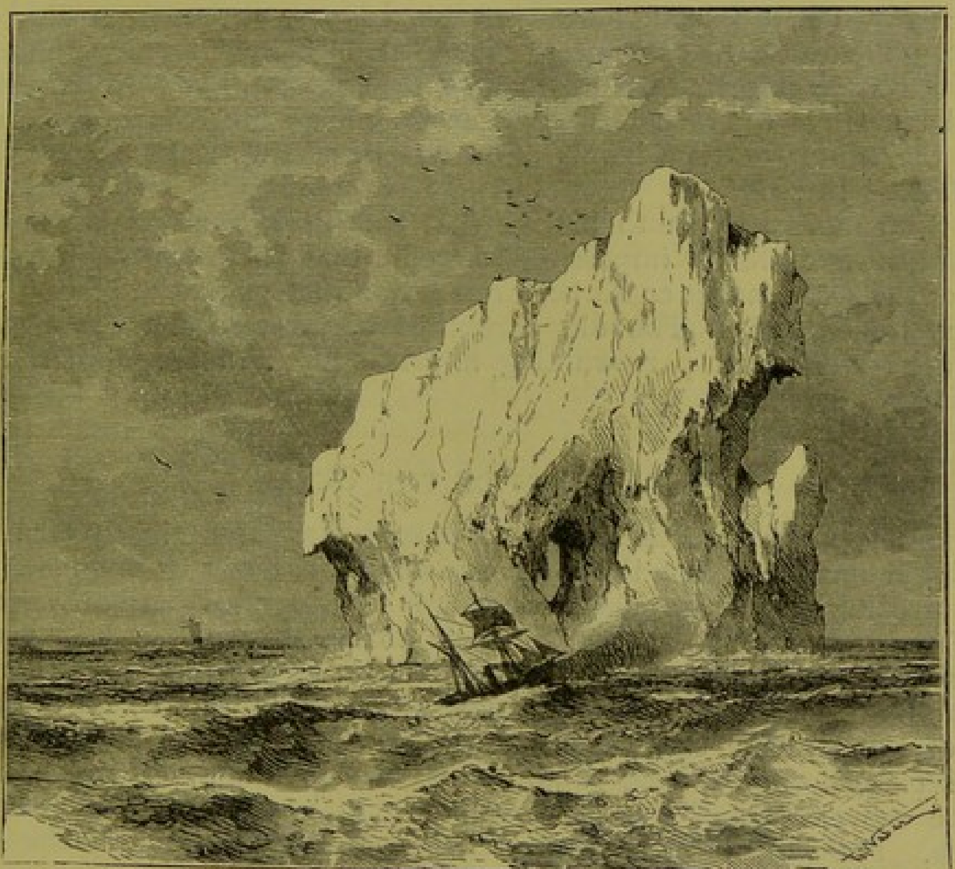
Icebergs have, on their first formation, simple, bold outlines, and only after the processes of melting and freezing up again have set in do they assume those weird and grotesque forms which delight the sailor, even while they warn him to shun the dangerous approach of these giants of the seas; for their grand massiveness gives but a deceptive idea of solidity: a mere nothing, the beat of a wave, the loosening of some small pinnacle, may be enough to shatter them to their base. Sometimes a single blow with an axe has been known to make an immense iceberg break up with a noise like thunder, overturning huge blocks of its ice, and burying the adjoining boats beneath the waves. Indeed, improbable as it seems, the mere sound of voices has been known, in isolated cases, to bring about the catastrophe. Scoresby relates that on one occasion seven men were rowing in a boat through Isefiord: it happened that a boy in the boat struck the side with the pole, two feet long, when a huge block fell from the nearest iceberg, and dragged the boat

SNOW DRIFTS AMONG THE PACK ICE.

with down it into the water. This phenomenon must doubtless be ascribed to the unequal strain of the ice, and it is to the same cause that the thunder-like cracks heard from within the bergs are due.

In the narrative of Captain Ross's second voyage, which treats of his unfortunate sojourn during many months in Boothia Felix, we read that this cracking and parting of the icebergs was heard every time that the temperature sank below 70° Fahr. Other travellers, among whom we may mention Kane, and, more recently, the members of the Austro-Hungarian Expedition, have related similar experiences in Franz-Josef Land and other places. We hear of icebergs breaking up with a loud report, with no apparent cause, and during a calm. Weyprecht, who studied the phenomenon very closely, says that, originally, and while the iceberg is not thoroughly hardened, it only throws off separate fragments of ice, and opens out new fissures; but when once the air and melted water have penetrated through every part, and, so to speak, have *decayed* the ice, then, by reason of the terrible and unequally distributed strain to which the interior is subjected from the snow water's gradually freezing in every direction, the whole iceberg breaks up and rends itself asunder.

These explosions are almost always confined to those parts of the iceberg which are exposed to the air. The far greater mass which lies below the water is not affected by them, because it lies in an almost uniform temperature, and is not penetrated by the freezing water. In proportion as the iceberg loses in weight by the constant thawing of some of its surfaces, it rises out of the sea; but as this loss is never uniform, the centre of gravity is constantly displaced from side to side, the iceberg leans downward, and finally



ICEBERG FLOATING UPON THE OPEN SEA.

topples over into the water, when it can no longer maintain its original position. Its fall is accompanied with loud crashings and explosive sounds, which are heard afar off, and have the effect of a thunder-storm; everything around is thrown into violent agitation; the neighbouring ice fields move and clash together; large blocks are dislodged from the icebergs around, sink heavily into the sea, and rise up again; the giant slowly turns and rolls over in the wave, and gradually settles down to rest in a new place and situation. For what was once above water is now hundreds of yards below, and new surfaces are exposed to the corroding influences of the air. Such, sooner or later, is the fate of every iceberg.

The explosive force within them is renewed every year, and sometimes throws off separate fragments, sometimes shatters the whole mass, and every summer the sun's irregular and capricious influence moulds and shapes the unwieldy monster, bringing to the light of day, and consequent destruction, parts which before were sleeping in seeming security far below the waves. Pitilessly the air begins its noiseless attack upon each fresh surface, and eagerly devours its new victim.

We have so far only treated of the iceberg in its own natural home ; but beyond these Arctic seas, and in more temperate regions of our globe, the same phenomena may be seen on a smaller scale, and attended with fewer dangers. In many a sea ice plays a prominent part during the cold winter months. The Baltic, for instance, has its masses of ice to show every succeeding year ; indeed, on its eastern coast the icy covering is sufficient to join the islands to the mainland. The islands of Aland form in winter the piers of a mighty bridge, by which it is sometimes possible to pass across from Finland to Sweden. This statement need cause us no astonishment when we reflect that in 1323 it was so cold that the southern part of the Baltic was frozen over, and allowed travellers to reach Dantzig from Copenhagen across its surface ; and that in the winter of 1848 bands of wolves came over the ice from Norway, and attacked Jutland.

It is far more difficult to believe that the Black Sea was frozen over in the year 401, and almost impossible to credit that in the winter of 763 the straits of the Dardanelles could be traversed on foot, or that in 860 the Ionian Sea was frozen over. The old chronicles which record these marvellous stories are for the most part wanting in credibility, and are seldom or never free from exaggerations.

Movements of the Ocean.

The sea, when contrasted with the land, has been rightly termed the *unresting* element. In fact, the surface of the sea is never for one instant seen in absolute repose. And, even if we pass in imagination from the restless play of the waves upon the surface down to the dreary depths of ocean, to those awful regions where the rising wave and crested breaker never penetrate, we find even here no perfect quiescence of the waters ; for the uneven strata of temperature cause a constant rise and fall of the liquid masses vainly seeking to regain their equilibrium. We shall find, upon examination, that the movements of the sea's surface may be classed into three great divisions. First, the ordinary and well-known rise and fall of the waves ; secondly, the tides ; and thirdly, the ocean currents. Waves are caused by the action of the wind descending with unequal pressure upon the surface of the water ; in some cases, however, they arise from some concussion at the bed of the ocean. The attack of the wind produces at first a gentle ripple of the sea's surface, and if it persists for some time, a powerful oscillation, a regular vibratory rise and fall, which, gaining strength in proportion to the strength of the wind by which it is caused, shows itself at last in those mighty billows whose power nothing can resist, and which, to the sailor's excited fancy, appear "mountains high."

The common optical illusion by which the particles of water that make up the wave seem to advance toward the spectator has long since been pointed out as erroneous, and can be refuted by the simplest observation made at the seaside, or by any sheet of water. For if a stone is thrown into the water, on the surface of which leaves or straws are floating, they will be seen to rise and fall, but not to advance or retreat from their position ; and there is also no advance of the watery particles of the wave in this sense of the word. What is meant by speaking of the quick advance of the waves is only the short duration of time which elapses between the formation of a second wave in the spot where the first has been. The higher the waves are, the more rapidly they seem to move forward, leaving the smaller ones behind them, so that it seems as if the smaller ones alone moved on the surface of the water, and the larger ones below it.

The long, slow, heavy advance of the waves, known as the swell of the sea, is most frequently marked in the open ocean. It approaches with majestic and deliberate roll, and forms, as it were, the substratum on which the local winds form their smaller wave systems. The swell is generally produced by causes far out of sight; it is the last throbbing of the waves which perhaps some hundred miles away lashed and tore up the sea in the passion of a storm which has probably died wholly away where it began its course. On certain seas, and along certain coasts where the regular trade winds are blowing, the swell is seen in its most imposing form. But, as a rule, the movements of the wave are the very type of irregularity and caprice; for, as Reclus has it, "not a breath is wasted on the yielding surface of the seas, and the busy diversity of the ocean waves is but the visible reflection of the no less great diversity of the invisible currents of the air which have called them into being.

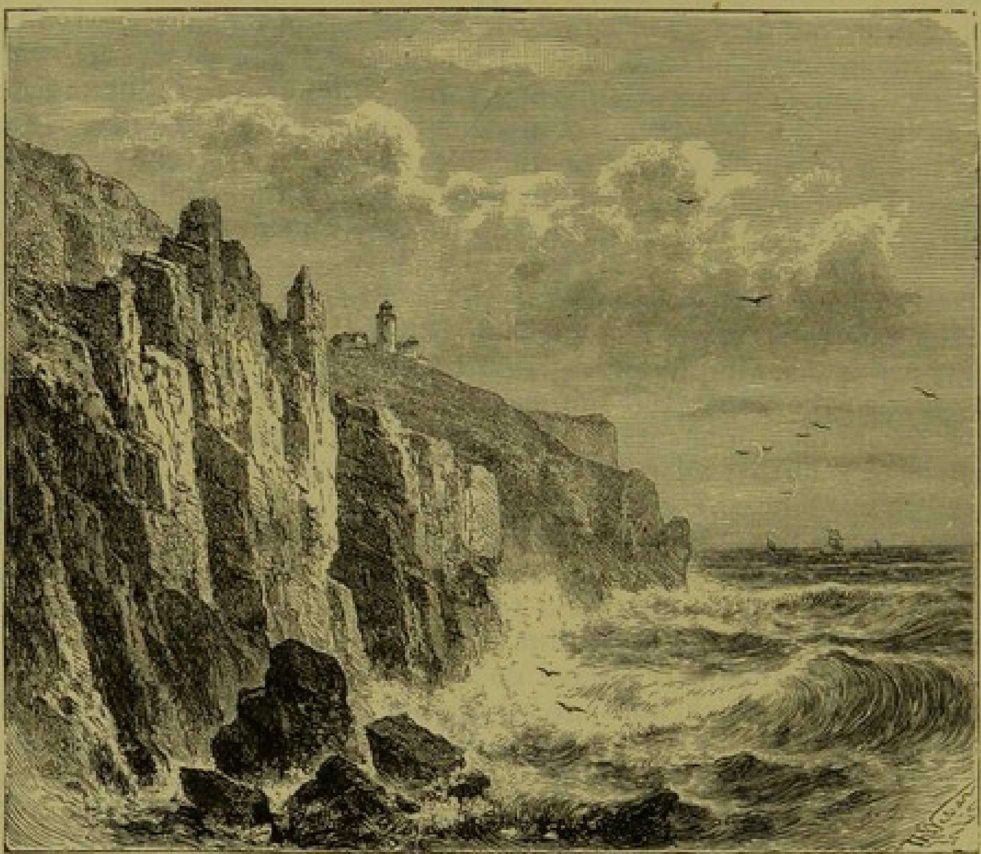
Questions are frequently asked as to the size of the highest waves which have been known at sea. The question is difficult to answer, because when the angry sea is throwing to their greatest height its foaming masses of water, the observer on the threatened ship has generally something else to do besides taking accurate measurements of the height of the billows. At any rate, it may safely be said that all reports of waves "steeple" or "mountain" high are greatly exaggerated. Scoresby tells us that in a storm on the Atlantic the waves rose to the height of twenty-four feet above the level of the water, but he adds that he never before saw so terrible a sea. The veteran sailor had specially directed his attention to the height of the waves during this particular storm, so that his testimony is of great weight. Moreover, we should not forget that every wave comes accompanied by a deep trough before and behind, which adds greatly to its majestic appearance. In the case related by Scoresby, the watery mountains, exclusive of their crests of foam, rose to a height of nearly forty-three feet above the trough of the sea in which the ship was lying.

In the southern Arctic Ocean, Wilkes speaks of waves ten and a half yards high; and waves of the same height are often seen at Cape Horn. And the writings of many seamen tell us of waves in the Atlantic, where its waters meet those of the Indian Ocean, which in a storm rise up to a height of fifteen yards and three-quarters. Dumont d'Urville even claims to have seen waves 136 yards high. Now even if we assume that these waves were measured from the lowest point of the trough to the highest of the crest, the measurement greatly exceeds that given by any other traveller.

There is a definite proportion between the height of a wave and the distance between it and its successor; in the case of the highest waves, the distance is about one-twelfth of the height. Therefore the trough between two waves of twenty-five feet in height would amount to 303 feet long; and we can form some idea by these figures of the grand spectacle presented by these moving masses of water. The length of the wave varies considerably; in a very troubled sea it may attain more than 105 yards; indeed, in the proverbially stormy Bay of Biscay, waves have been seen whose length was estimated at from 315 to 420 yards.

The rapidity with which the waves follow each other is no less unequal. With a moderate wind the advance is nine to thirteen miles an hour; but the speed of the waves in a storm is much greater. On the open seas, Ross estimates it at eighty-five miles an hour, but it appears that on an average it does not, even in the most violent hurricanes, exceed forty-five miles an hour. Such a storm wave, therefore, would only take twenty-three days to make its way round the globe.

The experiment, thanks to the intervening continents, is happily impossible; but the great waves occasioned by earthquakes have frequently traversed the whole extent of the ocean. The destructive earthquake which annihilated



SURF AT LIZARD POINT, CORNWALL.

the town of Arica in South America, August 1868, communicated an impetus to the mighty waters of the Pacific, and in fifteen hours and nineteen minutes a gigantic wave had crossed its surface from Arica to Chatham Islands, a distance of 5.520 nautical miles; thus proving the rapidity of the wave's advance to be 609 feet a second. If all other conditions are equal, the rapidity of the wave's advance depends on the formation and depth of the ocean bed, and the one can be calculated by the other. It was thus that the average depth of the Pacific was found to be 11,500 feet. In small and shallow seas like the North Sea and the Baltic, waves of the size of those found in the Atlantic and Pacific Oceans can never be met with.

Of course the depth to which the sea is agitated by the movement of the waves depends upon the height of the latter, as the high waves draw deeper strata of water into correspondence with their motion, but it is by no means established how far this movement extends downwards. According to certain experiments made by Sian, the movement of the water on the surface is perceptible at a depth of 196 yards; while according to researches instituted by Weber the effect is felt at a depth equal to 350 times the height of the wave. And it seems to confirm the latter estimate, when the sea is seen breaking over sunken rocks which lie more than forty-five yards below its surface; that is how we must account for the breakers which are seen where the configuration of the sea presents an obstacle to the deeper movement of the waves. Perhaps also the tide-wave, called by the French *ras de marée,* may be ascribed to the same reason.

This strange and terrible phenomenon shows itself from time to time on

THE SURF AT EDDYSTONE LIGHTHOUSE.

certain coasts, as a great wave rising suddenly, in clear, calm weather, out of the deep sea, and carrying before it all that lies in its path. If we suppose that in these places vertical masses of rock rise like walls from the bottom of the sea, and that submarine waves are dashing with great force against these walls, it is clear that they must occasion a great upheaval of the water overhead. From what we have said before, waves rising thirty feet above the level of the sea would be caused by disturbances 7,080 feet below. Generally speaking, however, the effects of even a violently agitated surface are but very slightly perceptible at a depth of from eighty to a hundred feet; and the coral fishers do not hesitate, even in the stormiest weather, to dive to the bottom of the sea, since they know by experience they shall find calm water in the depths below.

Where the force and dash of the advancing waves is broken against a steep, rocky coast, the sea surges wildly round it, covering itself with foam ; the force of the surf is proportioned to the depth of the sea on the respective coasts. These foam-covered breakers in a storm are one of the grandest sights in nature ; majestically the great waves roll onward, dash thundering against the rock, climb up its surface, to be thrown back headlong in the deep ; meanwhile other billows have advanced, and forced their way over retreating waves. Again they rush against the rock ; broken and lashed to foam, the watery masses sink back into the whirling chaos, to fling themselves the next moment with irresistible force against the rocky wall, and to renew the attack again and again. In stormy weather the waves rise above the summit of the Bell Rock lighthouse in Scotland—indeed, the famous Eddystone lighthouse (now in course of reconstruction) was sometimes completely enveloped in the surf, the waves pouring down like waterfalls over the massive building.

In order to form some estimate of the mechanical force of these advancing masses of water, we may remember that once on the coast of the Hebrides the waves tore away a fragment of rock nearly forty tons in weight ; that on the Irish coast a heavy block weighing ten tons was hurled upon the shore ; nay, that, according to Lyell's narrative, a rock more than fifteen tons in weight was thrown by the waves to a height of fifty-five yards. The great rocks, apparently massed in their places for all eternity, are in time worn away by the attack of the waves ; and yet our lighthouses, which are, as a rule, built precisely in the most dangerous situations, defy the violence of the raging sea.

When the sea is covered with fragments of ice, the swell is but slight, and the great rollers of lower latitudes have not space to form themselves ; such at least is the experience of all travellers in the Arctic seas, and it is asserted that if it were not for this comparative calm, no ship would ever return in safety from the icy regions of the pole. This beneficent calm does not appear to be always present in the Antarctic Ocean ; for we hear that Ross, in his famous voyage of discovery to the South Pole, encountered a fearful storm in these frozen seas, when the masses of ice were thrown into indescribable chaotic tumult. Nothing remained for the imperilled seamen, surrounded on all sides by these tossing and menacing blocks of ice, whose repeated shocks made the good ship shiver from mast to keel, but to wait in silent expectation for the inevitable. The waves were of equal size to those which are lashed into fury by the wind on the high seas ; but on their crests, and in their yawning troughs, countless blocks of ice kept crashing against each other and against the ship's sides as she was driven hither and thither. The swell did not subside till nightfall, when the shocks became so moderate in their force, that though any ordinary ship would have been shattered by them, they presented no more immediate danger to the *Erebus*. The cause of this sudden abatement of their violence was found to be a chain of great icebergs, which had gathered round the *Erebus* and her companion ship at some distance off.

We see, then, that in the Arctic regions the icebergs act with a tranquilizing effect upon the dash of the waves ; and in more temperate regions we hear that, according to the old saying, "oil thrown upon troubled waters will appease their fury." This was a fact well known to the ancients, and the Dutch naturalist, Linnæus, tells us that the sailors, in their voyages to Greenland, used to take with them casks of oil to still the waves of the sea. Franklin, who had heard much about this theory, thought that it would be as well to test by experiment how much truth there was in it. He went, with this end in view, to the shore of a lake on a very rough day, and poured a small quantity of oil upon the surface of the water. To his intense astonishment he saw that, as the oil spread over the water, the surface became smooth ; and that while outside the charmed circle there was a strong ripple, almost amounting to waves, within or rather underneath the thin coat of oil the water was calm and even.

Hugi made the same experiment on a very large scale in the Gulf of Tarento, taking with him tons of oil, which he offered to Neptune, and being rewarded by seeing the heavy swell of the waves disappear. It was found at night that the oil entirely destroyed the phosphorescence of the sea. The two brothers Weber, who have experimented on this subject in the most rational and scientific manner, did not forget to test the power of oil upon the sea. They found that the most different kinds of oil were able to smooth the surface, spreading quickly over it, and even pushing little particles before them. The proposal to make use of this calming property of oil to save a ship endanged by a storm at sea, although it has been seriously and repeatedly brought forward, is too absurd to be seriously refuted. A ship tossed by tempestuous waves upon the open sea does not remain quiet in one position, but is driven to and fro without cessation ; and it would be of little use to her if a few hundred square yards of the ocean were covered with oil, not to speak of the fact that no one has as yet tried the effect of oil upon the storm-tossed billows of the open sea.

The Tides.

Speaking generally, the sea has a daily twice repeated advance and retreat to and from the land, for which the names are respectively flow and ebb, the whole process being known as the tide. If we stand on the seashore at flood time, or high water, we shall see that for a certain period there is no apparent alteration in the height reached by the water. Gradually, however, the waves, in their ceaseless advance, are no longer able to reach the landmarks which they washed over a few minutes before. The surface sinks perceptibly, the waves slowly retreat from the shore, and gradually a large portion of the sands or shingle is laid bare. After awhile this retreat of the waves attains its farthest limit, the tide is at ebb, and after a short interval of rest it begins slowly to rise again. The whole proceeding occupies about twelve hours : for six hours the sea retreats, and in six hours is up again at high water mark. There is hardly any natural phenomenon which is more calculated to excite the restless curiosity of the human race, than the sight of on-coming thundering billows, with their sudden check and gradual retreat to within 30 to 50 feet of their former boundaries. One feels instinctively the mysterious presence of some mighty power, whom the immeasurable waters of the deep obey, and at whose will they advance and retreat, untameable as they are by any human power.

The phenomenon of the tides aroused the interest of the ancients, and Pytheas of Marseilles is said to have declared that the tide rose with the waxing and fell with the waning moon. The theory is erroneous, as we know, but it is interesting to see that in those far-off times the old Greek traveller had guessed at the connection between the moon and the tides. Practically the phenomenon must have been familiar to the Phœnicians, for those bold navigators sailed round almost the whole extent of the European coast to reach the Gulf of Riga, and they must often have been forced in their adventurous voyage to struggle with the mysterious laws of the tidal ebb and flow. But the experience and science of the Phœnicians is for ever lost for all other nations. Exclusively devoted to their commercial interests, these enterprising traders hid their discoveries jealously from the knowledge of their neighbours; and accordingly we find the sailors under Alexander of Macedon in great dismay and bewilderment because, having anchored their fleet at the mouth of the Indus, they found the ships six hours later left high and dry by the ebb of the tide. Aristotle, on the other hand, wearied himself in vain to explain the current in the narrow channel (Euripos) between the Grecian mainland and the island of Eubœa; and the problem was so far from being solved by later generations as to give rise to the legend that Aristotle, baffled and perplexed, sought death in the waves of the Euripos, with the words, "If I cannot comprehend you, do you comprehend me!"

Boats Stranded by the Tide.

During the middle ages no one thought of troubling himself with the explanation of any natural phenomenon; and not until the days of Galileo and Kepler do we hear of any more attempts to learn the reason of the tides. It is not necessary to mention any of their efforts in detail; we will only say that the ingenious Kepler despaired so completely of there being any mechanical explanation of the process, that he gave it as his opinion in solemn earnest, that the earth was a monster endowed with reason, and that its sleeping, waking, and breathing produced the effect of the ebb and flow.

It was reserved for the great mathematician, Sir Isaac Newton, to proclaim the appearance of the tides to be a necessary consequence of the great law of attraction, and so to bring to light the true explanation of the mystery. Before we go on to the theory of the tides, we must examine the process itself at greater length. The movement of the waters which we call tidal is found along all coasts which have uninterrupted connection with the open sea. Along steep, rocky coasts the water sinks, and along low, level shores it retreats, so that wide stretches of the sea's bed are uncovered, in some very level coasts, for several miles in extent. The retreat of the water is slow at first, then quicker, then again slower. After about six hours the retreat ceases, it is low water, and for about a quarter of an hour the height of the surface remains unchanged; then the return begins in the same manner, slowly at first, then more quickly, then again slowly until high water is reached, and there is another pause for a quarter of an hour. These pauses are called still water, or high and low tide. Where the surface of the sea is not affected by the presence of islands and narrow straits, and where consequently the tides can be observed to most advantage, they are seen to have three distinct kinds of movement, a daily, a monthly, and a yearly movement.

The daily movements, of which we have already spoken, consist of the twice recurrent ebb and flow of the tide. Now this twice occurring tide takes up a period of time which lasts rather longer than a day, for the average length of one tidal ebb and flow is 12 hours, 24 minutes, and 22½ seconds; the daily tides therefore equal twice that period, or 24 hours, 48 minutes, and 45 seconds. This period of time answers exactly to that occupied by the moon in returning to her vertical position over any given meridian. High tide occurs at a short interval after the moon has thus passed through the meridian, and low tide at an equal interval after she appears on the horizon, or 90° distant from the meridian. Now the moon crosses the same meridian on any given day about 49 minutes later than on the preceding day, and the tide which she occasions is therefore as much later in its appearance, until when the moon has completed her monthly revolution, the tides occur at any given place at the same time as at the time of the last new moon. This monthly or synodical revolution is accomplished in a period of 29 days, 12 hours, 44 minutes, and 3 seconds, reckoning from one new moon to another. The high tide is earlier on eastern than on western coasts, and above latitude 65° north the ebb and flow are scarcely perceptible. The tides are not always of the same height during this monthly period; twice in the month the lunar tide is highest, and twice lowest. The highest tides occur a day and a half after new or full moon; and these tides are called spring tides. The weakest tides occur about a day and a half after the moon is in quadrature, that is, after she has passed her first or third quarter, and are known as neap tides. At the time of the spring tides the sun and moon are both above the meridian, while at the neap tides they are separated by a curve of 90° or one quarter of the earth's circumference.

The spring tides themselves are not of equal height; those which occur at the new moon being higher than those caused by the full moon. The spring tides are at their highest when the new moon is found in that part of her orbit which is nearest to the earth. The yearly movement of the tides is calculated by the fact that the spring floods are highest at the time of the equinox, or when the days and nights are equal in length; the neap tides being then at their weakest: also that at the times of the solstice the spring tides are weaker and the neap tides stronger. Spring tides are higher in the winter than in the summer solstice. All other conditions being equal, the spring tide is greatest in January, and weakest half a year later; because, at the former period the earth is nearest to the sun, and at the latter farthest away from it. The highest tides thus occur when sun and moon are nearest the earth, vertical above the equator, and passing together through the same meridian.

We see at once then, by the brief summary just given of the mere actual phenomena, that both sun and moon play an important part in determining the conditions of the tides. It was reserved for Newton to discover and make known the great laws in obedience to which these phenomena present themselves to daily observation, as necessary and inevitable results of universal attraction. According to this law, every particle of matter possesses a power of attraction in proportion to its mass, and in inverse proportion to its distance. It follows, then, that a body of twice or three times the weight would from the same distance exercise twice or three times the attractive

SPRING TIDE.

force; and that if the attracting body altered its distance from the body attracted by it, its force of attraction would be proportionately diminished or increased. If we assume that the distance between the attracting and attracted bodies is doubled, the former can exert upon the latter only one-fourth of its former power; if the distance is three times as great, only one-ninth; if four times, only one-sixteenth, etc.

Starting from this universal law of the attractive force of matter, it is not difficult to gain some idea of its effect upon the ordinary processes observed in the recurrence of the tides; and, with the help of Newton's discoveries it would have been possible to predict their necessary effect of the changes of ebb and flow. We shall perhaps see this more clearly if we examine more in detail the special relations of the sun and moon. We will therefore imagine the earth as a sphere completely covered over its whole surface by the ocean, as in this form we should find no hindrance to our observation of tidal phenomena, the obstacles and deviations caused by the land being wholly removed. Turning then to the diagram, let A B C D E be a sectional figure of the earth, with E for the central point: let F J K G represent the surface of the surrounding sea, so that F A, J B, G C, K D represent a circle of water. Let the moon stand in M. Let a straight line be drawn from M to E in the earth's centre, and produced to K, and it will be found to touch the sea's surface at J, and land at the point B, which is nearest to the moon. On the other side of E this line will come in contact with D and K, the farthest points from the moon.

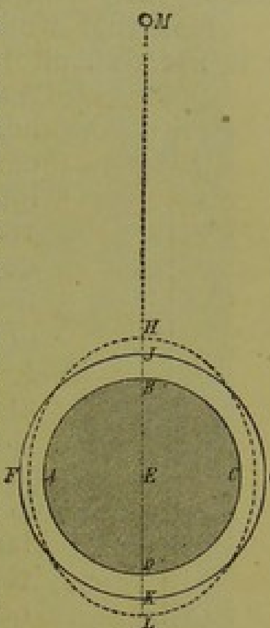


Fig. 1.

We will now examine what influence the attraction of the moon exerts upon these points collectively. The point J of the sea's surface, being nearest to the moon, will find itself most strongly attracted by it; and if it were not for the counteracting force of the earth's attraction, the water at J would immediately rise and precipitate itself upon the moon; but as the attractive force exerted by the earth retains its hold upon the water the moon can only diminish the earth's influence at the point J. By this the equilibrium is disturbed, and to replace it a rush of water towards the point J sets in, and the sea's surface rises to H: in other words, the high tide occurs. But if we turn to examine the point D of the land, it is at once obvious that here the moon strengthens the earth's power of attraction, because both are working in the same direction, D E; and the attraction is also strengthened at the point K.

It is natural, then, to imagine that the distance between K and D must be lessened, but a little closer attention will show us that this is not the case; but that, on the contrary, the opposite result occurs, and the distance between K and D is increased. For we must remember that in obedience to the law which we stated previously, the attractive power of any body is diminished in proportion to its distance; and that in obedience to this law the point D will be more strongly attracted than K; and D will fall as it were together with the whole solid globe more towards the moon than K. The consequence of this is that a swelling of the waters, or high tide, will set in over K. The tidal wave C must, however, be a little lower than that in H; becanse the difference of the moon's power on D and K is rather less than upon B and J. At the same time as the high tides in K and J, there must be low tide at the points F and C, for the simple reason that the water is drawn away from these points to form the tidal wave.

According to these observations, the tide is nothing but the physical necessity by which the watery masses of the sea strive to restore the equilibrium disturbed by the action of the moon. In reality this attempt never can succeed, because the moon, always advancing, is constantly vertical above some place on the earth's surface; and the continual ebb and flow of the tide rises and falls without intermission in vain efforts to restore the sought for restoration of equilibrium. The watery ellipsoid created by the moon's attraction follows of necessity the moon's orbit round the globe. For instance, if the moon stood over the point B, the swell of the water at that place, corresponding to the apparent movement of the moon, will move westward; after an interval of six hours the watery valley of the ebb will be above the point B; another interval, and the second upheaving of the waters passes over the same place, to be followed by a second ebb; and lastly, when the moon reaches the meridian over B, by the returning flood.

Now that we have learnt something of the daily movement of the tides, it is not difficult to understand the monthly movement. For this purpose we have only to remember that the moon is not the only heavenly body which exerts an attractive force upon the earth, but that the sun has also a considerable and analogous influence. The attraction of the sun upon the earth is indeed 180 times greater than that of the moon; and if the tides depended wholly upon the strength of this attractive force, the sun would create such a tide as would render a great part of the globe uninhabitable.

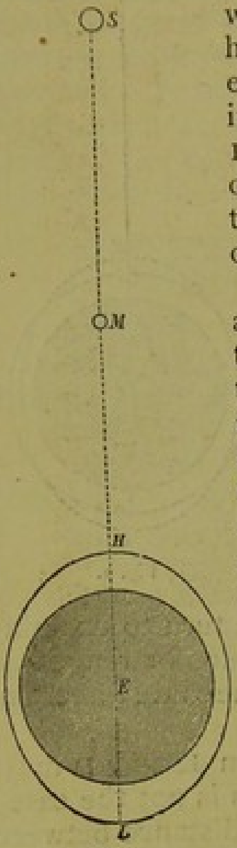


Fig. 2.

But we must never lose sight of the fact that the tides are occasioned by the *difference* of the attraction exercised by the moon upon certain parts of the earth's surface, and that this difference is greater in the attraction of the moon, which is smaller than the sun, but nearer to the earth, than in the larger but more distant sun. A simple calculation shows that the tide produced by the sun is nearly half as large as that occasioned by the moon. When then these heavenly bodies are working in the same direction, the tide must be greater, and weaker when they are acting in contrary directions.

At the time of new moon (fig. 2), the moon at M and the sun at S are working in the same direction; their influence therefore must be strongest and occasion spring tides at H and L. At the full moon the sun and moon are found opposite each other, the moon at M and the sun at S (see fig. 3), and in this case also their influence is strongly felt, each heavenly body occasioning a spring tide at H and L respectively. The tide at H, however, will not be so strong as in the former case, because, according to what we said before, the tide produced by the attraction of the sun is rather weaker than that produced by the attraction of the moon; the sun's power, therefore, will be least felt at H, and the moon's at L.

We see now why the spring tides must be higher at the time of the new moon than when she is at the full. As to the causes which call forth the neap tides at the first and third quarter of the moon's course, they are seen at a glance from another diagram (fig. 4). We see here how the moon at M works upon the watery masses of the earth's surface so as to produce high tide at F and G, and low tide at H and L. The effect of the sun, on the contrary, tends to produce the opposite result, low tide at F and G, and high tide at H and L. But as the attraction of the moon upon the water is twice as great as that of the sun, the result of their combined forces will be a weak tide at F and G, and a corresponding ebb at H and L.

As regards the yearly movements, we must notice that the greatest force of attraction is exercised when the tide-producing heavenly bodies are vertical above the equator. This is the case with the sun at the time of the equinox in spring and autumn, while at the summer and winter solstice it reaches its greatest distance from the equator. The great force of the spring tide in January, compared with those which occur six months later, is explained by the fact that the sun is nearest to the earth in January, and farthest from it

VEGETATION IN INDIA.

six months afterwards. It must not, however, be forgotten, with reference to all that we have said upon this subject, that water has a power of resistance, and therefore only yields slowly and gradually to the force of attraction brought to bear upon it. It is this power which shows itself in the retardation of the tides, so that, for example, the spring tide does not set in until about thirty hours after the joint action of the sun and moon; and this same power works with a diminishing force upon the strength of the tide.

It was assumed, for the purpose of facilitating our explanation, that the earth was covered by the ocean in every part, as it then presented no obstacle

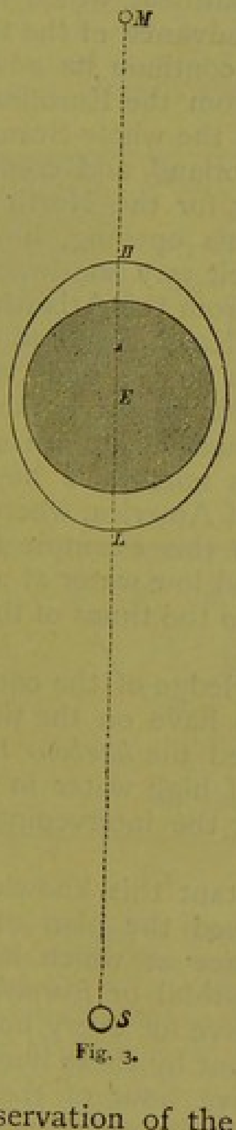


Fig. 3.

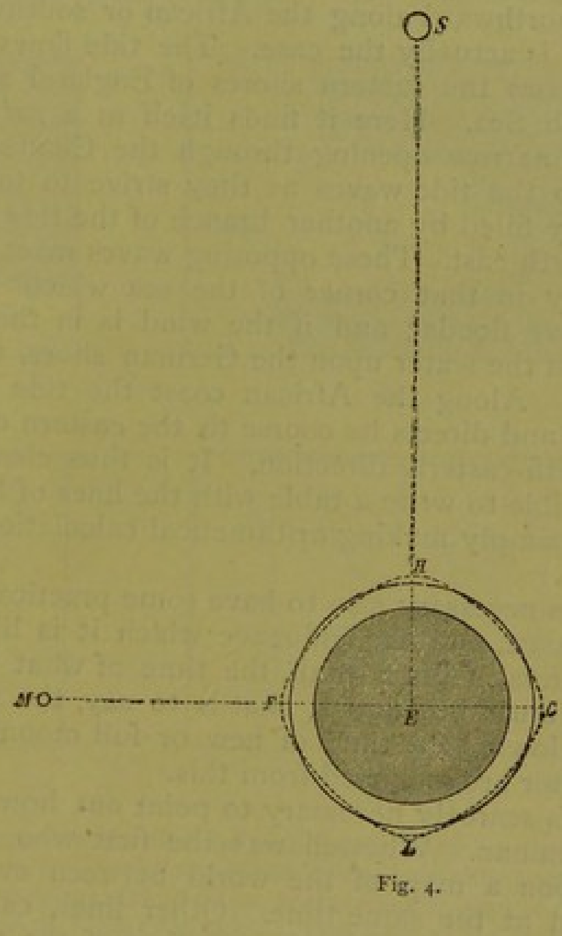


Fig. 4.

o an observation of the regular movements of ebb and flow. In reality, owever, the earth consists of land and water, and the great masses of land xercise a very strong influence upon the tidal wave. It is only in certain arts of the ocean that this wave can attain as it were its full formation; for he most part it is checked, turned aside, and affected in numberless ways, by he masses of island and continent which lie across its path. For instance, we nd that in the harbour of Tonquin there is only one tide in the twenty-four ours. This anomaly is explained by the formation of two straits through hich the tidal wave has to enter into the harbour. The situation and con- truction of these two straits is such that the tide flows through one earlier than through the other, the difference of time being such as to entirely do away with one ebb and flow.

We said also that the tide flows from the east westward; but if it come in contact with any land, it is forced to deviate from its direct course, and follow the coast line. By this delay it is unable to keep up with that part of the tide wave which encounters no obstable, and therefore has a shorter distance to traverse, so that both the time of high water and the direction of the waves are greatly modified.

We have an example of this on the eastern coast of the Atlantic Ocean. If we look at the projecting part of the African continent, which is nearly under the Tropic of Cancer, we see at once that an advance of the tide from east to west is impossible. The tide wave can only continue its advance by flowing northward along the African or southward from the European coast. And this is actually the case. The tide flows along the whole Scandinavian coast, passes the eastern shores of England and Scotland, and comes out in the North Sea. Here it finds itself in a *cul de sac*, for the North Sea has but one narrow opening through the Channel. This opening, however, is closed to the tide waves as they strive to force their way southward, for it is already filled by another branch of the tide wave from the Atlantic flowing to the north-east. These opposing waves meet in the North Sea, and occasion, especially in that corner of the sea which belongs to Germany, the most destructive floods; and if the wind is in the quarter to drive the swollen masses of the water upon the German shore, the consequences are still more terrible. Along the African coast the tide presses northward beyond the equator, and directs its course to the eastern coast of America, where it turns in a north-easterly direction. It is thus clear from this example that it is not possible to write a table with the lines of high and low water at any given spot by simply making arithmetical calculations as to the times of the moon's quarters.

It is necessary also to have some practical knowledge of the construction of the coast, and the influence which it is likely to have on the time of the tide's arrival. First of all, the time of what is called the *harbour tide* of the locality must be known; that is to say, the time of high water in the afternoon following the time of new or full moon, as all the intervening times of high water are reckoned from this.

It is scarcely necessary to point out how important this knowledge is to every seaman. Whewell was the first who conceived the plan of drawing lines upon a map of the world between every place at which high water occurred at the same time. Other lines, called co-tidal or *isorachian*, were to be drawn to indicate the position of the tidal wave for every hour of the day. The originator of this idea hoped to represent by these lines of contemporaneous high-water time for every successive hour of the day the different positions of the crest of the tidal wave in its advance round the world, accompanied by another attendant wave which follows it at an interval of twelve hours, both of them sending out branch waves into the narrow seas.

This alluring promise was too attractive to fail in exciting universal interest. German scientific men took upon themselves to fill up the gaps which were left upon Whewell's chart for lack of personal observation or because of conflicting testimony; and they filled them up as seemed best to them in the studious leisure of their libraries. The consequence is that these co-tidal lines have a place of honour to this day in many a German school atlas, where they may be looked upon as the airy vision of a futile imagination. Whewell himself, fifteen years after the publication of his chart, found out that all attempts to trace the path of the tidal wave over the open ocean, by means of observations made on the coast, must result in failure.

No one can observe the tide wave in the high seas to any practical purpose; we are forced to assume its presence, but can only demonstrate it when it breaks upon our coasts and rushes up our rivers. If the whole globe were uniformly covered with water, the average conditions of the tidal wave would depend wholly upon the moon, and at every place on the same parallel high water would follow the culmination of the moon at the same interval of time. The points at which it would be high water at the same moment would lie upon the same meridian, or at least upon a curved line, which, corresponding in curve with the lines following it, would intersect the equator vertically at a certain distance from the meridian over which the moon was placed. These curves would represent the co-tidal lines, and would complete their revolution round the globe in twenty-four hours and forty-nine minutes. If every hour is occupied by one co-tidal line, these twenty-four curves would

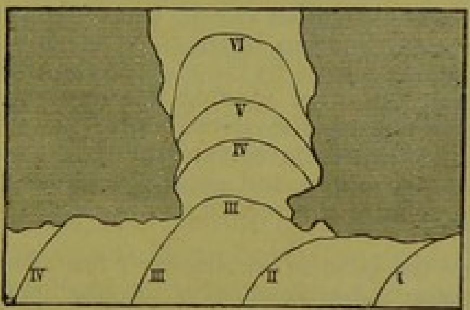


Fig. 1.

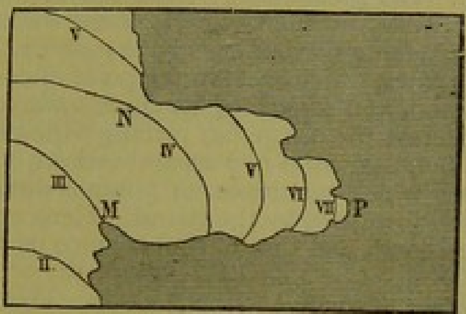


Fig. 2.

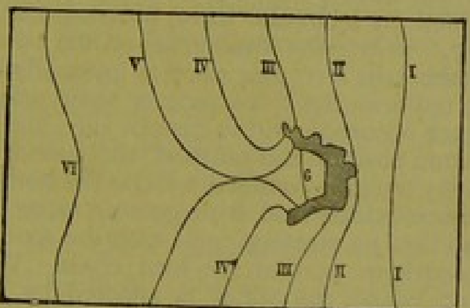


Fig. 3.

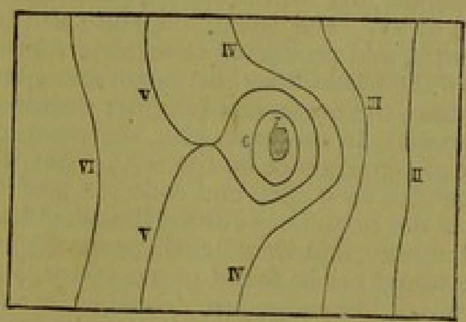


Fig. 4.

intersect the equator in twenty-four equal parts like the meridians. Now as the equator is 24,899 miles, or 21,600 geographical miles in circumference, every isorachia would advance with the rapidity of 1,014 miles, or 900 geographical miles, at the equator, and of course with diminished speed in the smaller circles of higher latitudes. This then would be the rapidity with which the crest of the tide wave would advance over the surface of a globe like our own if it were covered evenly with the ocean. But if a continent of great extent stretches from north to south, it will receive no tide from the east, but only from the north, south, and west, and this tide has different laws than that which flows in the open ocean.

The same thing holds good of seas interrupted by many tracts of land. If a narrow channel flows between two coasts, say from north to south, one part of the tide waves will turn aside, and instead of continuing the westward direction which they received from the original tidal wave, will intersect vertically the longitudinal axis of the channel, and bring the tides to its coasts. The speed of the wave will depend principally upon the depth and regularity of the channel. The more uniform are the depth and formation of the coast, the more even and parallel will be the co-tidal lines, because the conditions of the wave's formation are the same. If the water is shallower near the coast, the tide's advance will be most rapid in the centre, the sides will be left behind, and the line will describe a curve. See fig. 1, where part of the tide line III flows into the North Sea, and forms there a new succession of tidal lines, which are all curved. Let fig. 2 be a continuation of the northern sea, with a bay lying to the east, whose southern promontory is M, and its northern N. At M the wave flowing northward enters the bay in an easterly course, and continues its way to the north. At N it divides, and while the principal part flows on to the north, the other part presses forward along the northern shore of the bay. The attendant waves on the north and south shores of the bay advance to the point P, and there unite. The promontory N is a point of tidal divergence, the waves part there; while the converging point is at P, where the two tributary branches meet. It is easily seen, then, that high-water time along the shores of the bay will be later than at the promontories M and N. As the waters of a bay are generally shallower than those of the open sea, and the waves are checked and hindered in their movement by the bed of the bay, the rapidity of the tide is, generally speaking, less than that of the ocean tides. The intervals, therefore, between the lines will be smaller, and the lines closer together.

From the Atlantic to the German Ocean the distance of the hourly co-tidal lines diminishes to one-twelfth of its original size. Let fig. 3 be an island in the middle of the ocean. The lines I and II are but slightly affected by the coast line of the island; the third line is kept back by the island, although it has passed the obstacle on the north and on the south. The same check befalls line IV; but as the northern and southern advance is more considerable, the convex parts of the wave turn to meet each other at each end of the island. In line V these convex lines have met, and thus one tidal line can be regarded as consisting of two parts, which meet in the point of contact; the one having its two ends on the shore of the island, and stretching its curve towards the ocean, the other running like an unbroken wave across the ocean, but turning with a sharp curve towards the island. After these lines have met, they form two separate waves, VI, with a backward movement towards the island, and VI, which continues its original direction over the ocean, and gradually recovers the position disturbed by the island. Here we find the point of divergence on the eastern shore of the island, and that of convergence on the west.

Let fig. 4 be a shallow part of the ocean, where the islands are smaller; the effect on the tidal lines will now be greater. The waves move more slowly over the shallows, and those immediately following press more closely together, while to the north and south of the shallows the pressure is less. The centre of the line will be held back by the shallows and the islands, and the northern and southern parts, which have outrun it, will meet beyond the island at VV. The island therefore will be surrounded by a circular wave, pressing towards its centre, and producing concentric lines at 6 and 7. When the two curves on the western side of the island have met again and advanced farther, the irregular curve is gradually lost, and when the ocean bed becomes deeper and more uniform, the lines recover their original convexity. In this case, also, the point of divergence occurred on the eastern side, and the point of convergence on the west. But if in the same position the north of the island was surrounded by a deep and wide sea, and the south by narrow, confined waters, the northern part of the irregularly curved line would advance more quickly and with greater force than the southern, and would encircle the island alone, so that its meeting point with the southern wave would not be found in the centre, but in the southern part of the west coast. When tide waves like those just described meet round an island, the water is affected by their united influence, and other times for high water than the original ones are the result.

The circumstance that until a few years ago all the observations upon the tides were restricted exclusively to the French and English coasts, and that with almost exclusive reference to the practical necessities of navigation, had occasioned very faulty conceptions of the connecting law which underlies the phenomenon considered as a whole. It had been found that in western Europe, on the above-mentioned coasts, the spring and neap tides, with the corresponding ebb tides, occurred on an average two and a half days after the moon had reached the positions in which she produces them. The time at which the tide followed the new and full moon was not always the same in the different harbours, but was sometimes rather more or less than that we have mentioned. In theory the high tide should have happened exactly at the same time as the moon reached her culmination, and to explain the discrepancy it was supposed that the moon occasioned no tide at all, or only a very slight one, in the Atlantic, and that its power must be restricted to a part of the sea at some distance from the French and English coasts, from which the daily ebb and flow of the waves spread over the surface something after the manner in which ripples are formed by throwing a stone into a pond.

The connection of the oceans among themselves caused it to be taken for granted that these waves passed daily over the whole length of the Atlantic, after having traversed the Indian Ocean, which they entered again from the east to the south of Australia. But their course began, it was supposed, in the South Pacific, where lies the focus or generator of the tides. Whewell had undertaken to point out the course of this watery tide by the times of high water, which were more or less correctly indicated on the mariner's time tables at the respective seaports. But the attempt was found to be a failure, unless it was possible to admit that the tide wave, without any apparent reason, progressed for awhile with extreme slowness, and suddenly developed an almost incredible rapidity.

In spite of these difficulties and misconceptions, Whewell's idea had gained ground on all sides, and was at last to bear good fruit. The investigations of Schmick, made since the year 1873, threw much light upon the subject. They started from the following reflections :—If the sun and moon exert, as they assuredly do, a tide-producing influence upon the waters of the ocean, their influence must be universal, and not merely local. The delay observed in the appearance of high tide must exist, therefore, in every part of the world, and be due to other causes than those imagined by Whewell. This reasoning could probably be proved if the advance of the waves was observed for any length of time near the supposed focus and birthplace of the tides.

Schmick began his experiments by making observations for a whole year on the curves of the tidal wave as they were marked with unfailing accuracy by a self-registering machine at Sydney (Australia) ; and he combined with his observations on the waves a study of the corresponding positions of the moon. What, then, was the result which his investigations established beyond a doubt ? It was that high and low water in Australia, close to the supposed source and home of the tides, were just as much behind the appearance of the moon in her syzigies (when in conjunction with, or opposite to, the sun) as upon the French and English coasts.

But these Australian waves were soon to contribute valuable help to a scientific comprehension of the delay, when a grand and terrible exhibition of the forces of nature had taught their students how to read their lesson aright. This event was the great Peruvian earthquake, which happened in August, 1868. It had affected a great part of the bottom of the sea, and created roller waves of prodigious size. These waves had spread in circles over the Pacific, and so reached Sydney, among other places, and had been duly registered by the machine, with their size, time of succession, position one to another, and, most important of all, at the time of the ordinary daily tides.

The indications thus given established three things : 1st, that these waves on the Australian coast flowed in exactly the same curve on the daily tidal ebb and flow as the Peruvian earthquake had placed them, according to the easily ascertainable daily curve of the tidal ebb and flow in that place ; 2ndly, that they succeeded each other in diminished size at fixed intervals ; 3rdly, that they rose and fell on the sea's surface for about three days in succession, and always exactly in the same place of the crest of the tide which had originally carried them across.

The first result proved beyond all doubt that the daily tide at Sydney, besides the rise and fall of the water locally produced by the moon, was made up of tidal waves originating on the west coast of South America. The second result proved that all the waves of the sea, including the tidal waves, were reflected from opposite coasts; for the waves at Sydney were easily proved to be the same as those thrown back from the north-west shore of New Zealand. The third result showed that the lunar tidal waves took about three days to spend themselves, just as the waves created by the earthquake, and that in the case under notice the rapidity of both sets of waves was exactly equal. As, therefore, the tidal waves produced by the sun and moon are made up of a rise and fall of the ocean surface, which lasts for three days, the primary or tide wave of the day itself, and the return waves of the two preceding days, which are reflected from the corresponding coast, the highest tide will be increased by the return tides which it will encounter on the two

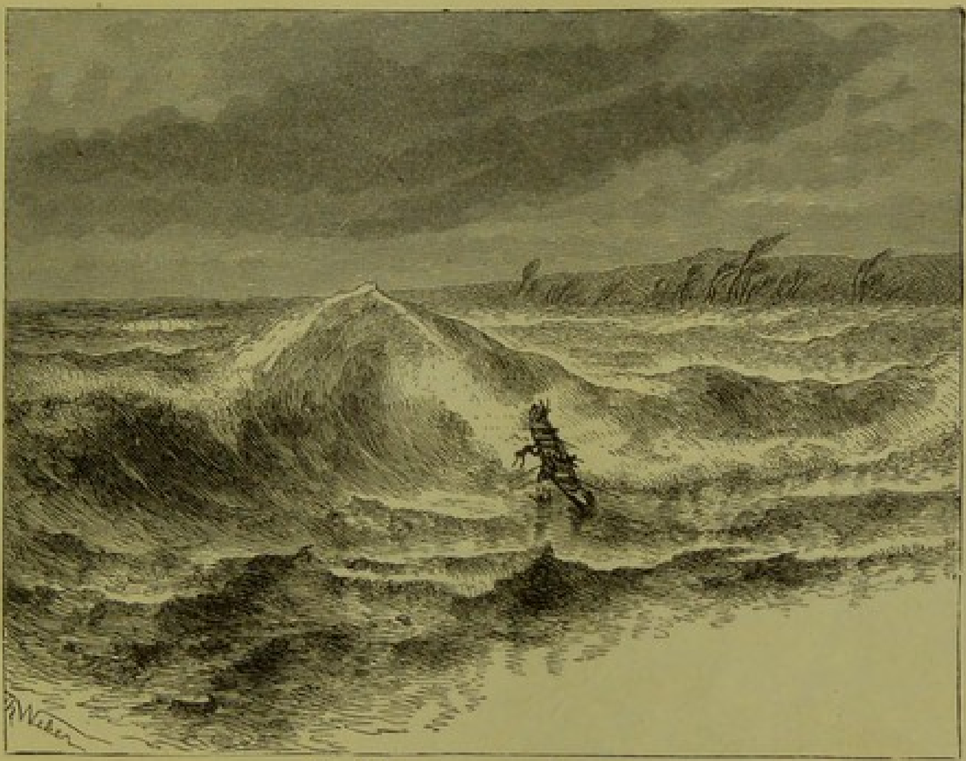
DEVASTATION CAUSED BY THE FLOODS AT HALLINGEN IN 1834.

days following its occurrence, and will not reach its maximum height till the third day. In like manner the ebb is at its lowest two days after its occurrence

Schmick has shown this connection between the delay of high and low tide and the position of the moon in the heavens, not only in his detailed observations of the tides on the Australian coast, but also in an equally long study of their phenomena on the coast of San Francisco, in California, and in a series of shorter observations made in other parts of the Pacific, Indian, and Atlantic Oceans, and on the Mediterranean, and has found them confirmed in every particular, all the perplexities occasioned by the irregularities of the tides in each locality being removed by his discoveries; so that at the present moment Whewell's theory of the co-tidal lines is victoriously established.

Among the most remarkable of the tidal anomalies is that noticed in the Euripus, or narrow strait between Eubœa and the coast of Greece. It is called the Chalcidian whirlpool, although there can hardly be a question of a whirlpool in the case. From the new moon to the first quarter, and from the full moon to the last quarter, the waves of the sea flow up and down in this place, and the daily tide is later by one hour. From the first quarter to the full moon, and from the last quarter to the new moon, the tide is, on the contrary, very changeable, and sometimes the ebb and flow occur as often as seven times in one day. The incoming tide occurs at such times when the current flows to the south-east, and the ebb when it flows to the north-east.

The grandest and most destructive effects of the flood tide are seen in storms blowing from the north-east upon the coast of Schleswig. Between the mainland and the sea there lies an archipelago of small islands, between which are dangerous sandbanks and flat reaches of sand and clay. These reaches are the *débris* of what were once the fertile and populous lowlands of North Friesland, which were only separated from the mainland by a shallow trench. The stormy sea, however, waged incessant war upon its coast, and in the course of centuries washed it away. All that remains of it is the district now called Halligen, which is almost yearly the victim of terrible floods. Anything like agriculture is rendered impossible

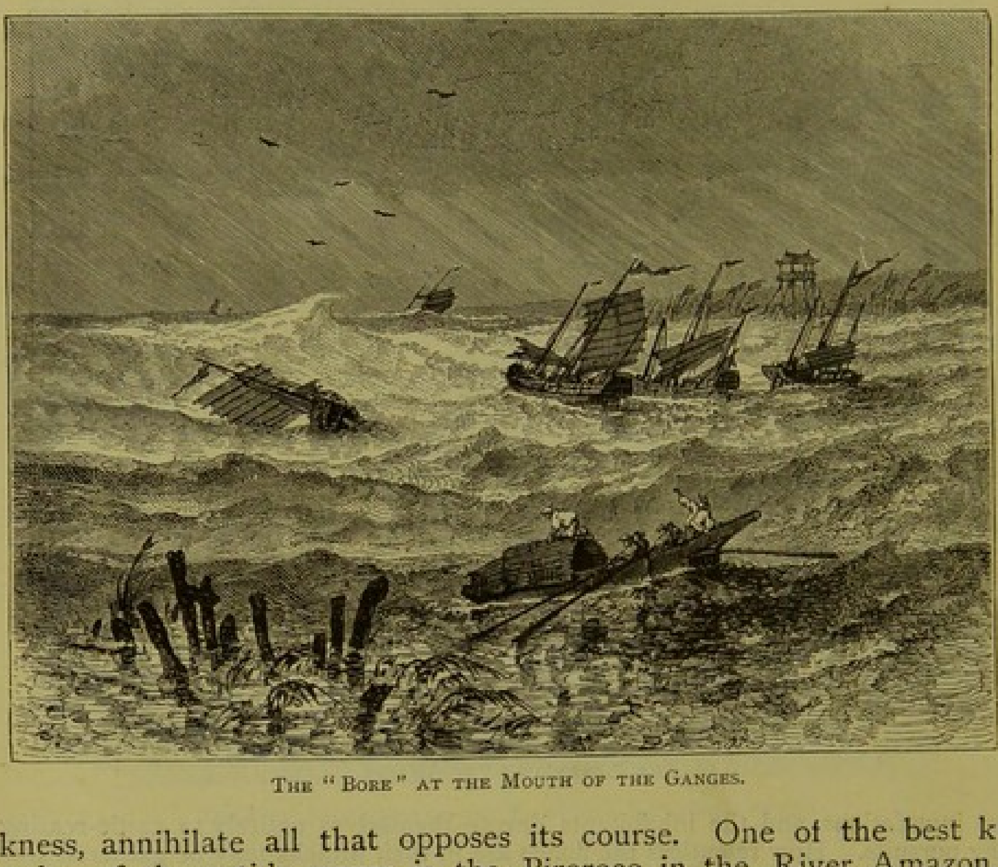


THE PIROROCO ON THE AMAZON.

by these inundations, and the inhabitants devote themselves entirely to cattle-rearing and seafaring pursuits. How relentless the floods are in their attacks may be gathered from the records preserved since the eleventh century to the present day, which mention that no fewer than one hundred and fifty "great" floods—smaller ones the North Frisian does not trouble himself to count—have devastated the islands; that is, one in every six years. The saddest memories were left behind by those of the years 1300 and 1362. The former tore away the whole western coast of Sylt; not one of the many harbours then existing was left, and where the storm-tossed ships used to find a safe shelter, they now run the risk of stranding. All that was left undone by this flood was finished by the terrible midnight flood of 1362. There was not one district in North Friesland where villages and churches were not engulfed.

On an October night in 1834, a part of Halligen and all that stood upon it became the prey of the devouring waters. The flood often rushes up with such rapidity that the sleeping inhabitants are only awakened by the noise thundering against the walls of their houses. There is then no time to place the cattle in safety; every one has to think of his own life. In terrible anxiety the families flee to the gables of the houses; the walls can offer but a poor resistance, the water bursts them in, and the unhappy people see all their goods carried off, the sport of the waves, which thunder through the heavy pillars that support the roof on which they have fled for refuge. To seek safety in the boats would be to run to certain death, for no boat could live in that raging surf; and if the pillars of the roof give way, all is lost. It seems as if nothing could exceed the horrors of such a night spent face to face with death, where, owing to the roar and boom of the wind and wave, the husband cannot learn whether his wife is saved, and the mother cannot hear her child's cry for help. And yet the records of the storms in Halligen tell of still darker scenes of horror. In the middle of the last century, says Weigelt, the flood tore up the coffins from their graves, the corpses were dashed against the walls of the houses, and into the rooms of the affrighted people, who saw in the midst of the howling storm the dead appear to summon the living. Here surely is a subject for a ghastly ballad.

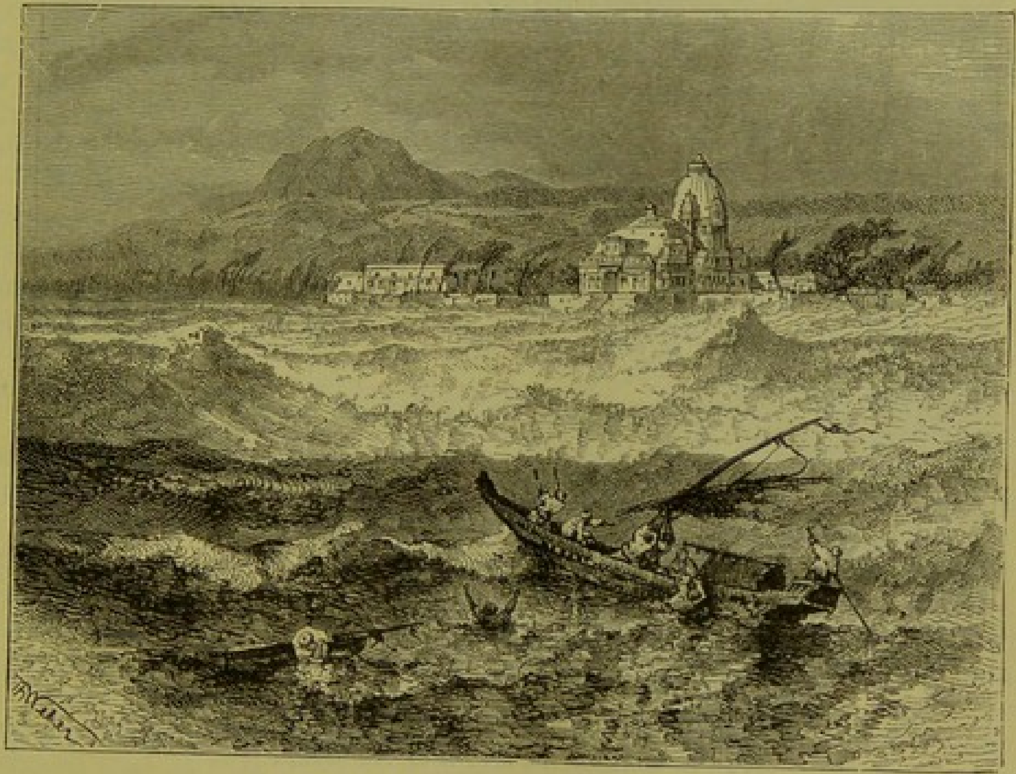
When the tidal wave rushes up the mouths of rivers where the bed of the stream suddenly narrows above its mouth, the grandest and most terrible phenomena are witnessed. The spectator sees with horror a gigantic wall of water rise from the river bed, and advancing with irresistible force and



THE "BORE" AT THE MOUTH OF THE GANGES.

quickness, annihilate all that opposes its course. One of the best known examples of these tide waves is the Piroroco in the River Amazon, first described by La Condamine. This giant river pours through its trumpet-shaped mouth an immense volume of water into the Atlantic Ocean, and that in a direction diametrically opposite to that of the tidal wave. The powerful current of this queen of streams rushes far into the ocean, thrusting the salt waves away on either side, until the tide flows to meet it, and hurls its masses of water against the river current. At first it seems as if the river would gain the day; but the invisible might behind the tidal wave cannot be long resisted. Closer and closer the sea's waves press forward, rise higher and higher, until they break down the motive power of their foe, and rush roaring into the channel of the stream. When, owing to the position of the sun and moon, the tidal wave is at its strongest, a wall of water, thirty feet high, rises at the mouth of the Rio Para, and, like a giant waterfall, runs up the stream swift as an arrow from the bow, crushing, shattering, and trampling down with the noise of thunder everything that lies across its path, making the very rocks quiver to the massive foundations. Here and there, where the bed of the Amazon is unusually deep, the great wave sinks and hides itself beneath the surface, to rise suddenly again when the water is shallower, and continue on its path of desolation. The points at which the Piroroco vanishes are called Esperas, or halting places, because the sailor waits there while the fearful portent passes by.

A tide wave, equally destructive in its effect, is the "Bore," at the mouth of the Ganges. At the time of the spring tides the bore rises to the height of twenty feet, and rushes up the stream with incredible rapidity: gaining in height in proportion to the increasing narrowness of the river bed. Still more terrible is the tide wave known at the mouth of the Chinese river



Tide Wave at the Mouth of a Chinese River.

Thientang. The inhabitants call it the Thunderer; and if its speed cannot literally be said to equal that of the lightning, it may, without exaggeration, be compared to that of our express trains.

If we turn to Europe, we find that below Bordeaux, where the Dordogne empties itself into the Garonne, the wind blowing strongly from the west, the whole tide wave is concentrated in the former river. The water rushes up the Dordogne at the rate of eighteen miles an hour, doing terrible damage, but the phenomenon is happily only of short duration. The people living in the neighbourhood call it Le Mascaret. A kindred wave known as the Bore, or Eger, appears at the mouth of the Severn, where it pours into the Bristol Channel.

The Bristol Channel is thirty-seven miles wide at its mouth, near Lundy Island, and gradually contracts between that place and Severn Lodge, which is eighty-one miles distant, to a width of only two miles. The mouth of the river is supposed to be at Severn Lodge, because at low water the width of the river bed is narrowed to about a quarter of a mile by the so-called English Stones, a rocky bank running across the river. Through this narrow channel the waters of the spring tides rush with frightful velocity, especially during the last ebb and the first flood. Above the English Stones the river bed rises steeply, and becomes shallower; its width also diminishes; and at Newnham it is only 2,000 feet wide at high water. The height of the spring tide at Lundy Island is twenty-seven feet, and it steadily increases as far as King's Road, at the mouth of the Avon, the crest of the wave rising and its base sinking. Simultaneously with its greater height the wave gains in swiftness, and advances at the rate of thirty-six to forty-seven miles an hour. The development of the wave, both in height and speed, is favoured by many different circumstances, among others by the gradually rising ground, and by the funnel-shaped bed of the Bristol Channel.

The incoming wave sets in motion great masses of water in the remote districts of the bay, and these masses suffice to make the wave rise to a greater height in the narrow parts of the river, and also to complete its development in a shorter time than usual. When the great wave, now forty feet high, has passed King's Road, it encounters its first obstacle at

Tidal Wave at the Mouth of the Severn

Severn Lodge; meeting first the English stones, and then, higher up the river, instead of a deep arm of the sea, only a shallow river bed. The result of these checks is immediately seen; for although the crest of the wave continues to rise, its base can no longer sink, but rises at Sharpness about fourteen feet higher than at King's Road, and at Newnham again fourteen feet higher than at Sharpness. The height of the wave then is diminished at Sharpness to twenty-nine, and at Newnham to sixteen feet, and the speed is reduced first to twenty-one and then at Newnham to nine miles an hour. The wave cannot undergo these great and sudden changes without incurring great loss and injury. There is not enough water in the stony bed of the river to allow of the development of its base; and instead of beginning with a gentle, swelling curve, it begins with a foaming mass of water from two to four feet high, which rushes violently up the stream from Sharpness to Newnham, and still higher. The sound of the advancing bore is heard from a great distance, long before it is in sight; it increases from one minute to another, till it becomes like the roar of a great waterfall; at last a white, seething mass is seen spreading straight across the stream, and in a few moments the untroubled surface of the water is changed into a wildly tossing sea. From this point the sea rises with greater speed; after a short interval the sound of the onward pressing wave dies away, and the further development of the tide takes its regular course.

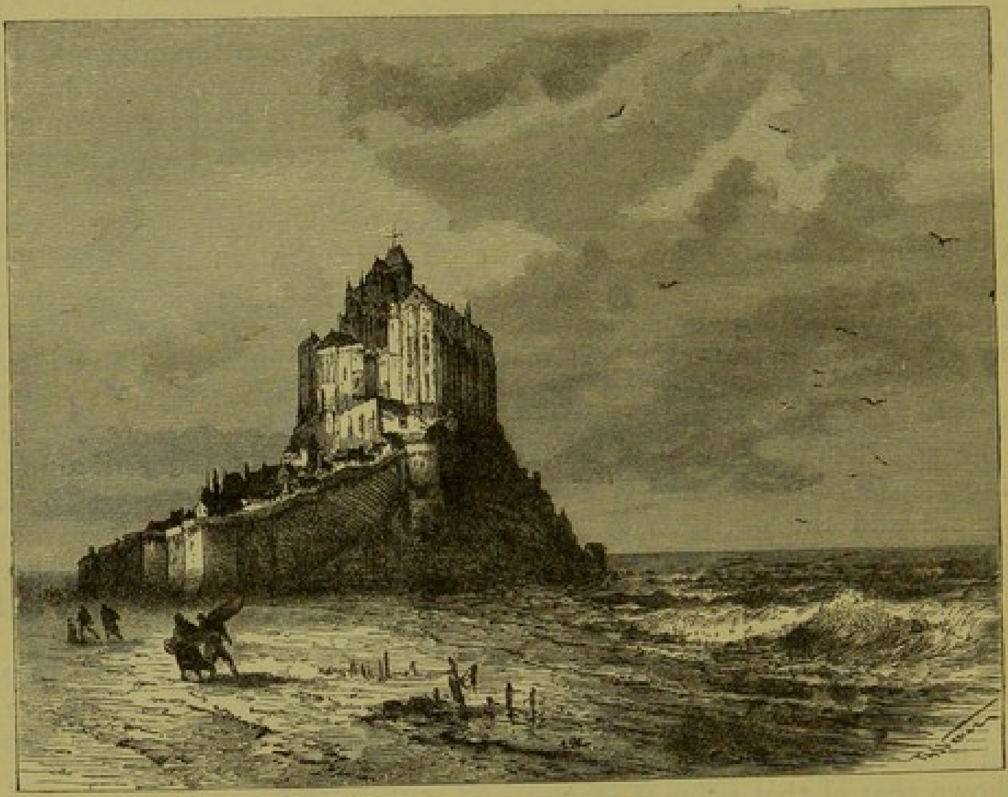
Although the sea rises in a scarcely perceptible degree at the mouth of the Seine, the first wave of high water is seen at Quillebœuf, advancing with a mighty rush, taking up the whole width of the river, and rising at times to a height of ten feet. It is followed by other waves called *éteules*, which dash together with great violence and a continuous chaotic movement which threatens to engulf everything within their reach. The river recoils with the speed of a horse at full gallop, the vessels lying at anchor are torn from their moorings, the fields on the river-side rent away, the sandbanks set in motion, and even the bed of the river wavers for many thousand yards between its steep banks. It is an astonishing spectacle to watch on a calm day, amid the quiet of the surrounding scenery, this sudden outbreak of the foaming waters, lashed into fury by some unseen power, and after awhile sinking as suddenly to rest. The phenomenon is occasioned by the shallowness of the river bed. In consequence of the grand series of dikes which have been constructed at Quillebœuf, and carried as far as La Roque and the point of Berville, the bed is now about one yard deeper; but although some of the most dangerous places are now rendered safe, the *traverses*, or shallows, have only been thrust further back by the dikes; and if the latter were continued farther they would endanger Havre, where the currents have already been sensibly affected by them.

The speed with which the tidal wave runs round the ocean is very far from uniform; it varies according to the obstacles presented to its advance. If the whole globe were covered by an unbroken sea of equal depth, the crest of the tidal wave at the equator would have an hourly speed of 1,014 miles. As a matter of fact, however, this maximum rate of speed is never attained.

In the Atlantic Ocean, 20° N. lat., the tide wave is said to advance at the rate of 600 geographical miles an hour. In the Pacific Ocean, 60° S. lat., the speed is estimated at 450 nautical miles an hour, but along the adjoining coasts the advance is considerably less rapid. Between the south of Ireland and the northern extremity of Scotland, the rate of advance is only fifty-two geographical miles. As a rule, the longest waves are the swiftest, and this length depends not only on their having free room to form and develop across the surface, but also on the depth of the sea.

The speed of the tide wave, however, varies, not only from place to place, but also from moment to moment, and up to the present time science has been unable to procure any really definite measurements. Lenz has made careful investigations with respect to the speed of the wave at Cuxhaven, and has shown that at that place it reaches a rapidity of fifty-eight miles an hour. He describes the process which he observed from low water, as follows: a strong current flows down seawards, and does not come to a standstill until after an interval of an hour and a half, when the water has risen for about a yard, and the inclination of the surface toward the current has reached 1 in 42,000. Now sets in the change; the current turns, and the tide wave flows in, attaining its highest speed of forty inches a second, an hour and a half before high water. Then it becomes weaker, but continues even after high water, and not until the surface has gone down eighteen inches is it still water again. The ebb now begins, gains continually in strength and speed, and is at its swiftest six hours after high water, that is, running two yards a second. Fifty-one minutes later it is low water once more, and the same round repeats itself again, although with manifold changes in the separate details.

The mathematical investigations which the famous Laplace was one of the first to institute touching the various phenomena of ebb and flow, show that in the open seas the height to which the tidal wave rises depends, *cæteris paribus*, upon the depth of the sea. If the sea has a depth of one geographical mile, the tide wave at the equator would reach a maximum of thirty-nine feet; but at double that depth it would only reach the height of six feet. The deeper the sea, the less would be the height of the wave, until it reached its minimum height of three feet, which is the height it would always have if the sea's surface had everywhere and at every moment the form demanded by its equilibrium. It has been found upon investigation that the height of the tide wave at Saint Helena is three feet, and the same thing is true of the Pacific, at least in that part which is unbroken by islands. In the Atlantic the tide wave increases in height up to 50° N. lat., and then diminishes. Along the coast of Portugal the wave rises from eleven to twelve feet, along the French coast from fifteen to eighteen feet, and along the Irish and Scotch



St. Michael's Bay.

coasts to eighteen feet. Over a shallow bed the wave reaches of course a greater height; for instance, near Saint Malo, where it is forty-five feet high.

"The grandest spectacle presented by the tide wave on the European coast," says Reclus, "is in St. Michael's Bay, where in the centre of the waters rises an island of black granite, which stands out in bold contrast to the wide stretch of the sands, with abbey and cloister, fortress and dungeon, steep precipitous cliffs, and Titanic piles of rock upon rock, defying the lapse of centuries. At low tide the far-reaching plain surrounding it looks like a bed of ashes; but when the foaming tide, quicker than a racer at full speed, rushes up its scarcely perceptible incline, it is the work of only a few moments to transform the bay into a desolate waste of turbid water, whose troubled waves force their way up the river mouths as far as the quays of Pontorsan and Avranches. When the tide has turned, it retreats with equal rapidity, laying bare the sandy levels for more than 1,093 yards from the coast, and showing the muddy channels of the subterranean delta, which form here and there treacherous funnel-shaped mud banks in which the unwary traveller may easily be ensnared. At the spring tide the mass of water which rushes into the bay may be estimated at more than 400 cubic miles, and even at the lowest neap tides the mass of water which flows over the sand twice in the twenty-four hours is not less than 200 cubic miles."

At the North Cape the spring tides are found to be only from two to three feet high; at Cuxhaven, on the German coast, the average difference between high and low water is found to be from ten to twelve feet. "If," says Bobrik, "the wind has been blowing strongly from the south for about three days, and afterwards veers round to the south-west, the tide wave rises to twenty feet. If this state of things is followed by a storm from the north-west, it rises still six or eight feet higher. Then if a continuous storm from the west meets the flood coming in towards the north-west, it will last for six, or perhaps from ten to twelve hours; and the mass of water, now grown to the height of thirty feet, threatens and overflows the shores of the Elbe and the Damme."

The tide is but of insignificant height in the Mediterranean; at Toulouse and Naples it reaches about one foot in the harbour; in the port of Antrim, according to Trevelyan's observations, only to fourteen inches. In the Adriatic Sea, on the other hand, it is far more perceptible, and specially because of its situation at the northern extremities. There, at Toaldo, the tide rises at the time of the new and full moon from three to three and a half feet; and at the times of the first and third quarters to one and one-third foot. In the Baltic alternation of ebb and flow is so slight that it can only be recognized by means of observations continued for several years.

On the west coast of the Atlantic the sea rises very high in certain places; Fundy Bay being especially notorious for its high tides, the waves in its inner bay reaching the height of fifty feet. At St. John's, New Brunswick, a dazzling waterfall is seen at low tide rushing down in the background of the harbour; but as the flood advances onward towards the shore, the waterfall decreases in height, and finally disappears wholly beneath the incoming rush of the salt waves, which rise at last to the highest terrace, and allow vessels to enter the natural basin formed above the waterfall. The greatest height of the spring tide is said to be at Hudson's Bay. It is said to reach the height of sixty-seven feet, and a story is told of the captain of a steamer who cast anchor in six fathoms of water, and to his great astonishment found that six hours later he was able to walk round his ship dryshod.

Very high waves are recorded on the coasts of the Indian Ocean. Thus the spring tides in the Gulf of Martaban are twenty-three feet, and in the Gulf of Cambay even thirty-six feet high. The proof that this great height is occasioned by the formation of the coast is found in the fact that at Rodriguez, on the southern shore of the Indian Ocean, the height of the wave is only six feet.

Scarcely any perceptible ebb and flow is seen in many enclosed seas and lakes, and that for the simple reason that the wave has not room to develop itself; gentle vibrations of the surface of course appear, but it requires very close and long-continued observation to observe and record them. They are seen most clearly in Lake Michigan, on whose western shores, at Milwaukee and Chicago, self-registering measuring machines are in use. At the latter place the height of the spring tide is only one quarter foot; and high water sets in half an hour earlier than in Milwaukee.

The force demanded for the production of the measurements of ebb and flow is something beyond all human efforts to command. If we estimate the average height of the tide at the very modest calculation of one foot, we find that in the course of a single day a mass of water amounting to 7,680 cubic miles is rolled round the globe. That is indeed an undertaking of truly bewildering greatness. In order to be able to grasp one of its aspects, we will quote from Oppolzer as follows: "If we reflect that the greatest building raised by the hand of man, namely, the great Egyptian pyramid, amounts to about the millionth part of sixty-four cubic miles, we shall own that it is not too much to assert that never since the human race began has man been able by his own power, aided by that of the animals subject to him, and the artificial motive forces which he has learnt to wield, to impel even one cubic mile of matter round the world."

In consequence, then, of the attraction of the sun and moon upon the waves, an amount of power is brought to bear upon them, far beyond every other motive power at our disposal. This power may be utilized for various purposes, and yet in the present stage of civilization we make little or no use of it. Nasmyth and Carpenter have treated of this subject, and warn us that in our eagerness to avail ourselves to the full of all the force contained within our coal-mines, which lavishly provide us with such vast stores of force-producing material, we lose sight of many other valuable sources of power, and, among others, of that offered to us in the rise and fall of water. We can transform it, by the aid of water-mills, into any mechanical force we please. Here and there we find such mills still in existence, but as a general rule they are superseded by steam, with all its adaptability and convenience; and so they are deprived of their share in contributing to the benefits conferred upon mankind by the inventor of these wonders of mechanical art. We must not forget, however, that by our thriftless consumption of coal we are taking capital out of a bank into which no deposits are made. We are exhausting a store which is not infinite, and the time must come when we shall have to look round us for other sources of power. Perhaps we may then return to the use of water as the motive power for mechanical purposes.

This problem is of special interest and importance to the British nation, because of her great extent of coast and the number of rivers up which the tidal wave makes its way. The source of power thus placed within our reach is of almost incalculable extent; for it is not only the flow of our rivers, but also their rise, which may be turned to account. Within certain limits, it matters little to the mechanician, whether the "foot-pound" work which is placed at his disposal is in the form of great masses rising to an inconsiderable height, or smaller masses rising to greater height. And there is no reason why the tide wave should only be made use of when it reaches our rivers; on the contrary, our coasts may be encircled by a line of factories. The million tons of water which are lifted twice a day to the height of several feet could be rendered useful according to ready-made plans; for modern science has demonstrated the convertibility of every kind of force into any other kind, and thus has opened the way to a system of convertible force which may be of the highest value in reference to the experiments of which we are speaking. For instance, the force of attraction or gravitation can be converted into electricity, and electricity gives us the wonderful power of conducting force to a distance without displacing matter, or even setting it in motion. We use this force in the telegraph, by producing power at one end of a wire, and making use of it at the other end, which may be thousands of miles away, to ring bells, or set needles in motion. What we are able to do in this way by the exertion of the small amount of force which is necessary in telegraphy we can also do with any greater amount of force. A "*tide-mill*" could convert its mechanical energy into an electro-magnetic machine, and in the form of electricity its force could be sent inland through a system of wires, and there converted either into mechanical or motive power. Of course a considerable amount of power would be wasted, but then the power would cost nothing in its first production. Another method of transplacing power, which has already done good service, is by making use of compressed air. A more extensive system, admirably worked out by Sir W. Armstrong, is the transplacing of water power by means of an accumulator, which is so commonly used in the docks for the purpose of turning cranes, etc. As the task of the mechanical engineer consists in converting and rendering interchangeable the forces of nature, a wide field is here presented to his inventive genius—a field on which he will one day find himself obliged to direct his attention to rendering the power of the moon's attraction serviceable to the mechanical necessities of his fellow-men by the intervention of the tide.

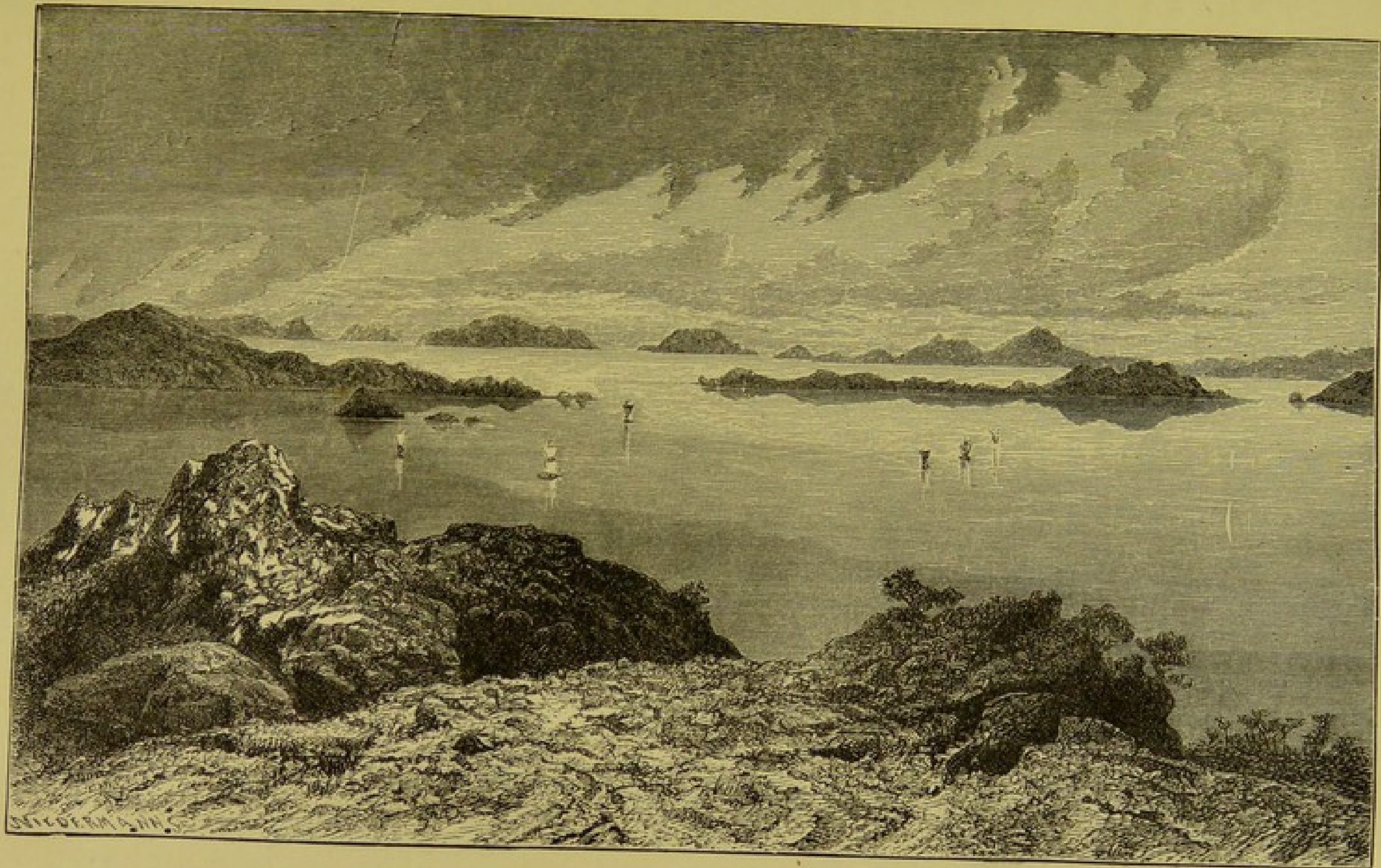
The phenomenon of the tide is still playing an important part in the physical history of the earth, a part which was little dreamt of in past ages; it is retarding the rate at which the earth turns round her axis. The great philosopher Kant had already conjectured that in the course of ages the duration of the earth's rotation must be lengthened—in other words, that the collective duration of day and night would increase—but Robert Mayer was the first to call attention in 1838 to the cause of this retardation. He showed that it was occasioned by the tidal wave which is always flowing from the moon's meridian. Let us imagine, he says, that the moon is stationary, while the earth rotates on her axis from west to east. A mountain to the west of the moon in her meridian would, in consequence of the moon's attraction, occasion an acceleration in the rotation; but when it has passed the meridian, it will produce a retardation of equal amount, and from the same cause. Now a mountain which remained stationary to the east of the moon's meridian would, in consequence of the influence received from the moon, strive to lengthen the earth's rotation. The ocean tide is to be looked upon as such a mountain, always placed to the east of the moon; and, influenced by the moon's attraction, it must inevitably act upon the speed of the earth's rotation. Practically the retardation is not considerable, as it amounts only to one second in the course of many thousands of years. And it is remarkable that at the same time the tide should also present a means by which man, in theory at least, may be enabled to exert an influence upon the rotation of the globe on which he lives; for if the tide power were used on any large scale to set machinery in motion, and if the process were continued for a sufficient length of time along immense extents of coast, it is certain that, according to the laws of mechanics, a gradual slackening of the speed at which the earth rotates round her axis would inevitably be effected.

The Sea's Currents.

The sea, like the mainland, has its streams and watercourses. Mighty rivers intersect it, and carry along for hundreds of miles the enormous volume of their watery currents. In clearly defined watery channels there flow through the ocean streams which, as far as regards their quantity, far excel the largest rivers of the mainland, and which in one place carry the equatorial heat towards higher latitudes, and in another bring down cold waves from the Arctic regions to the sunny lands of the equatorial zone. Sometimes the currents show upon the surface of the sea such a clearly defined outline of their course, that the sailor can distinctly see that one half of his ship moves on the flowing waters of the current, while the other half is in the more restful sea beyond. The great and far-reaching influence exerted by the ocean currents on meteorological circumstances, and therefore on the flora and fauna of whole continents, has only been fully recognized at a recent date, when, for instance, the wonderful fact was discovered, that the development of European culture, so far as it is influenced by the temperature and climatic circumstances of our hemisphere, depends wholly upon a current flowing in the Atlantic Ocean. And if we descend from the earth's surface to the bed of the ocean, we find even there powerful currents, and soon perceive that they exert great influence on the animal life of the deep sea, according to the mineralogical character of their deposits.

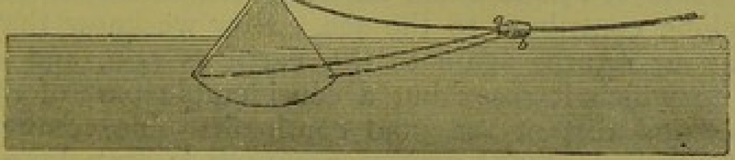
Carpenter compared, some time since, the appearance of northern types of animal life at the bottom of the sea, where the surface showed a very high temperature, with that of Alpine plants upon the summits of mountains in tropical regions. If the North Atlantic Ocean could be emptied of its waters, and the deposits of its bed could be subjected to the examination of a geologist, he would find that at certain spots they consist of a slightly fossiliferous sandstone, which contains within itself fragments of older rocks in which the rare fauna is principally of northern type. A geologist would without difficulty, by means of plausible assumptions which come very near the truth, be able to account for these appearances. But on going forward for a few miles he would come upon a kind of chalk formation rich in lower forms of marine animals, which indicate the presence of warmer conditions of temperature. This contrast between the geological and mineralogical character at the same depth, and in districts which are unmistakably adjoining one to the other, would present greater difficulties to an explorer; nay, he would perhaps be forced to imagine some grand revolution of climate, if he did not happen to remember that above the ground which he is examining, submarine currents of very different temperatures have flowed, bringing with them, as they passed, the varying characteristics of widely different zones, and placing them in close juxtaposition. Thus we find the powerful, far-reaching influence of the currents both on the earth's surface and on the bed of the ocean, and we are led to recognize their significance and their bearing, not only upon geology and meteorology, but also upon the history and development of culture.

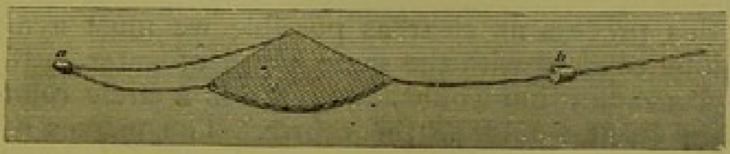
The sea's currents are divided into surface and under-currents, according to their position at only a slight depth below the surface or among the lower strata of the waters. Where the whole mass of water from the surface to the bed of the ocean flows in one direction, it is called a complete current. Surface and under-currents frequently flow in opposite directions; indeed, it is sometimes found that two surface currents flowing side by side are yet hurrying in different directions. Currents, as is well known, are named from the region towards which they flow, while winds are designated by the quarter from which they come. Currents are also divided according to their temperature into cold and warm, and according to their duration into constant and intermittent, the latter being frequently periodical; that is, they occur under cert[illegible] circumstances which repeat themselves at different times. The currents wh[illegible] only affect the actual surface of the sea are called drift currents. It is only in exceptional cases that the seafarer is able to detect the presence of a current simply by looking down from his ship: he is, as a rule, obliged to have recourse to artificial aids.



THE LADRONE ISLANDS

The method of determining the existence, speed, and direction of a current consists in comparing the position of the ship as given by astronomical observation with the so-called "dead reckoning" made by means of the log, and also by ascertaining with the help of the thermometer the difference of temperature between the regularly and irregularly agitated sea; that is, between the waters of the ocean and those of the intersecting current. The log is a simple piece of wood like that shown in the accompanying figures, with thin lines fastened to three corners. To one of these lines a small cylinder B is attached, while the ends of the two other lines are held down inside this cylinder by the stopper A. These lines hold the log when it is cast into the sea vertical above the water, where it remains while the log line runs out floating in the sea. The ship meanwhile goes on her course for about half a minute on an average, and then the line is drawn in with a sudden tug which pulls the stopper out of its case, so that the log falls horizontally on the water. The calculation is then made by measuring the length of line which has been run out.





It is easily seen how unsatisfactory this method is; for not only does it take for granted that the speed of the ship's advance is always uniform, so as to allow of the rate of movement for a whole day being calculated upon that of half a minute, but it leaves out of account the fact that the very currents which it desires to investigate have a direct tendency to hinder any accurate reckoning of the distance sailed over. Another disadvantage is that in determining the ship's position, the course according to the compass must be taken into account, and it is absolutely impossible always to keep in the prescribed path pointed out by the compass. Then the errors of the last reckoning made by means of the log come to swell the mistakes of the present, and it is not an unheard-of case that, apart from any change of current, and merely from unavoidable faults, the reckoning has been from 15 to 20 degrees away from the true position of the ship. These faulty data therefore have to be compared with astronomical conclusions when it is desired to define the position of an ocean current, and it is easy to see why the course of the currents even in those waters which are constantly visited by sailors are so imperfectly understood.

Franklin was the first to point out, in the year 1775, the importance of making observations of the sea's temperature in order to discover the presence of the currents. Williams also found, by means of numerous experiments, that the difference between the atmospheric temperature and that of the sea's surface is but slight, and that when there is a sudden rise of temperature the presence of a current may be assumed. The presence of objects floating on the surface afford also valuable assistance in pointing out the direction of a current, and more valuable aid still is rendered by bottles cast out from time to time, with the date and name of the locality, although of course these messengers can only indicate the starting-point and terminus of their journey, and are silent as to the stations they pass on their route.

The causes which produce the sea's currents are very various; for every power which in any way or at any place disturbs the equilibrium of the waters at once occasions a current. The chief cause is found in the unequal temperature of the sea. Near the tropics, where the greatest heat prevails, there is, of course, the greatest evaporation. How great this evaporation is cannot be accurately ascertained, but Maury estimates that in the tropical regions it amounts to at least 4½ yards in the course of the year. Starting from this very moderate computation, we find that in the tropical districts of the Atlantic alone, more than 100 billion cubic yards of water are carried into the atmosphere in the shape of mist and vapour every year. This mass of water represents a volume of 19,200 cubic miles, or six times as much as all the rivers of the globe contribute to the sea. Now we know that the greatest part of this vapour returns again to the earth as rain, and chiefly in the same districts in which it rose; but a considerable part of it is carried on to benefit other and distant seas and continents. To compensate for this loss of water in the equatorial regions a supply is sent down in the shape of currents flowing from the poles, and thus the hydrostatic balance is restored.

To make this process as clear as possible we must again imagine the earth to be a globe covered with the same depth of water. If this were the case, the greatest evaporation would take place in a circle round the equator, of which the line itself would be the centre. The masses of vapour driven forwards by currents of air would move towards the poles, and fall down on their way thither in the shape of rain. The sun's heat would thus constantly raise great masses of water, and transport them to the arctic regions. The balance thus disturbed, the force of the earth's attraction would immediately set to work to repair the loss, and the arctic currents being set in motion would flow toward the equator. If the earth did not rotate round its axis, these currents would flow in the direction of the meridians, and then we should have a southern current in the northern hemisphere, and a northern in the southern hemisphere.

Let us now see how these facts are modified by the earth's movement round her axis from west to east. In this case the current flowing from the poles proceeds from smaller to larger circles of latitude, the latter having a greater velocity of rotation from west to east than the former. Now the water arrives with the lower rate of velocity, and must therefore remain by a certain amount behind; in other words, it must assume an east-westerly direction. As it started on its way with a course directed from the poles to the equator, the result of the two combined directions will create a south-westerly current in the northern hemisphere, and a north-easterly in the southern. Where the two currents meet, they join, and form one current flowing from east to west. Under these circumstances then we shall find a powerful current flowing round the equator in a direction exactly opposite to that of the earth's rotation round her axis. But the circumstances which we have been assuming do not exist in fact; for the irregular formation of the continents present many obstacles to the connection of the oceans. We can only expect to see the abstract theory of the currents realized as a matter of fact in those regions of the ocean where the waters have their fullest course unchecked by the presence of islands upon their surface. Such is the case in the South Pacific Ocean, and here we actually find a mighty current flowing from east to west, just as the theory of the case had led us to expect.

We have so far taken into consideration only one factor in the production of ocean currents; but a little reflection will enable us to discover the presence of other causes likely to create, or at least to further, these phenomena. Mention has already been made of the trade winds on this subject; indeed, it was once the belief of many geographers that to these regular atmospheric currents the currents of the ocean were chiefly due. This opinion was combatted by others, who pointed out that the great equatorial current extended to a considerable depth below the surface. Was it possible, they argued, to suppose that the force of the wind upon the sea's surface could displace waters so far below, and create a current at a depth of 330 to 440 feet? Of course this question cannot be settled by mere reasoning; recourse must be had to experiments based upon a knowledge of the physical laws underlying the friction of fluid masses.

Not long ago Zoeppritz undertook the task of investigating this subject; and his conclusions are of great value for the theory of the ocean currents, for he proves that an initial motive force exerted upon the surface of a horizontal stratum of water can, as a matter of fact, create and keep up a strong current without the slightest difference of level; and therefore that the assertion that the trade winds can only produce superficial currents is erroneous, and must be abandoned.

Zoeppritz based his researches on the law already laid down by Sir Isaac Newton, according to which two adjoining strata of different velocities exert a mutual influence one on the other, by which the accelerating power exercised by friction is assumed to be independent of pressure, and corresponding in proportion to the difference of velocity.

Under certain suppositions, which are, however, very nearly realized in equatorial districts, Zoeppritz arrives at the following principal results. If the surface stratum has been preserved for an inalculable length of time in an unaltered degree of velocity, the whole watery masses will remain "stationary," that is, in a condition of movement not liable to any change of speed. The velocity would then depend solely on the depth of the water; it would decrease with increasing depth, and finally at the bottom of the sea would be represented by zero. Of course it is assumed that no other causes, such as under-currents, set in motion the lower strata of water. If by any alien cause, these lower strata are preserved for the same length of time in condition of movement, also "stationary," but in the contrary direction to that of the upper strata, there will be found somewhere between the two a level where the rate of velocity will also be expressed by zero.

It is remarkable that in this condition of movement, existing from immeasurable time, the distribution of speed is the same in a thin fluid like water as in a thick fluid like syrup. The influence of friction appears in this "stationary" condition, only in the participation of all the strata in the movement imparted from without to the surface alone. The advance of mathematics also allows the time to be reckoned at which each particle of water at a certain depth participates in the rate of speed communicated by the upper strata. Zoeppritz found in this way that it would take 239 years to impart to a particle of water 110 yards below the surface half the velocity of the superficial masses. He says further that it would take forty-one years to communicate one-tenth of the surface velocity to the same depth of 110 yards. These figures are well calculated to give us an idea of the length of time necessary to develop a change of velocity in the lower strata of the water. A "stationary" current, therefore, which is only affected by the depth of the water, will be influenced in an incalculably slight degree by superficial changes such as contrary winds, storms, etc., excepting, of course, upon the actual surface itself. On the contrary, the lower strata will be found to possess an average rate of speed varying very little with the lapse of time, and decided by the average velocity of the surface.

If the surface velocity is periodically altered by winds and storms themselves affected by periodical changes of the seasons, this periodicity when it has existed for incalculable periods, will be repeated in every lower strata for the same length of time, but with diminished oscillations as the depth increases. This diminution takes place with great rapidity; for at a depth of eleven yards the yearly oscillation has lessened to one-thirteenth; at 110 yards it is wholly imperceptible, the rate of the velocity corresponding to the "stationary" condition, when the surface has attained its average yearly speed. To gain an idea of the time required for a constant and long-continued surface rate of speed to change the condition of a motionless stratum of the ocean 4,400 yards beneath the surface to one of "stationary" movement, we will examine the following figures.

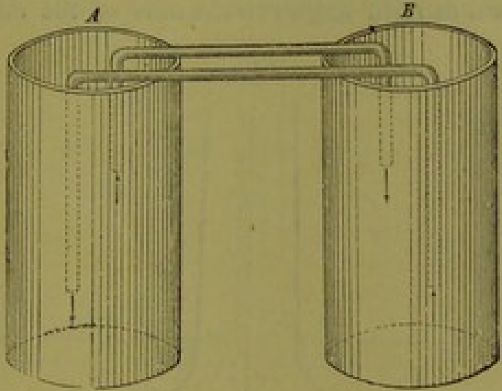
After the lapse of 10,000 years, only 0·037 of the surface rate of speed will prevail at a depth of 2,200 yards, or half the original depth. As then, according to the above conclusions, half the surface rate of the "stationary" movement exists at this depth, we see how far from the "stationary" condition the ocean is at present. After 100,000 years the speed at this depth would be $=0{\cdot}461$ of the surface speed, that is, very nearly the definite value; and it would only vary from that by $\frac{1}{1000}$ in the course of 200,000 years.

We have just shown by these figures how very slowly the surface rate of speed is carried down to the lower strata, even if perfect repose had previously existed in those strata. We conclude then conversely, that if at a given moment every drop of the watery masses had a certain rate of speed variable according to the depth; and if at the same time the surface remained in repose, this condition of repose would be just as slow in penetrating to the troubled waters below as the condition of surface movement was in reaching the quiescent lower strata; so that the same figures may be used to express the creation and disappearance of the same fractions of the given rate of speed. If then, for example, about 10,000 years ago, that is, at a time of which we have no historic records, it happened that by any cosmical disturbance the equilibrium of the sea was upset in such a degree as to cause the setting in of strong currents, the influence of that disturbance upon the conditions of the currents existing at the present moment would certainly be still in process of exertion, especially in the lower strata of the ocean waters, if the earth were, as we have been imagining, covered with water of an uniform depth of 4,400 yards. The presence of the masses of land would tend to weaken the results of former conditions of movement; not so much by the increased friction, as by the number of reflex and intersecting currents which would be called forth on all sides; meanwhile the slow development of the influence of local variations of movement established by the figures given above, necessitate the warning not to evade the difficulties of accurate calculation by accounting for every perplexity, as has been too long done, by reference to friction alone.

From these observations we may gain some idea of the causes which produce the surface currents of the ocean; but what are the laws and conditions of the submarine currents? What causes the chill Arctic currents of the ocean depths to flow towards the equator? Witte, the author of some careful treatises upon this subject, says that the water, warmed by the sun at the tropics, rises and spreads itself out above its original level. This process would cause a surface current towards the pole, and a submarine current towards the equator; but it does not seem as if this ready explanation was altogether sufficient. The surface evaporation, as we have seen, plays an important part in the production of currents, but so also does the unequal distribution of salt, which follows as one result of evaporation. If we assume that from an eighth part of the Atlantic Ocean a watery stratum of one inch in depth is evaporated, the result would be the same as if ten million tons of salt were added to that part of the ocean, and chiefly of course to the surface or the upper strata; and that is the reason that in the Arctic seas the amount of salt increases with the depth, while near the equator it is greatest in the upper strata of the seas. There is therefore no compensation of temperature in the waters of the ocean for the unequal quantity of salt.

Buchanan has subjected the distribution of salt in the Atlantic to a searching investigation. He first gave the course of so-called lines of equal amount of salt (equi-saline lines), basing his calculations upon numerous observations and experiments. Imagine a sectional division of the Atlantic, following the 26th to the 30th degree of west longitude. We shall find that along this section the amount of salt varies from the surface to the depths below, but by no means in the same degree. In the South Atlantic, for example, there exists from the equator to 8° S. lat. 2·7 per cent. of salt. At 12° S. lat. this amount of salt is found at a depth of 150 yards, and again at 29° S. lat. upon the surface. In the North Atlantic the same amount is found on the surface in lat. 14° N., after which it is necessary to descend to a depth of 400 yards before we meet with it again in 25° N. lat. It then rises gradually to the surface, where it is found in 40° N. lat. If these different points are united by a line, we have a wave-like curve which represents the equi-saline lines of 2·7 per cent. In the same manner we can obtain equi-saline lines of 2·6 and 2·5 per cent. In the Atlantic these lines sink from south to north, and the saltest water is found in that direction deepest below the surface. The heavier Arctic water of the depths has, then, a tendency to flow towards the equator, and in this tendency we gain some idea of the causes of submarine currents.

The unequal density of the superincumbent masses of water has great influence upon the double currents which are found in certain parts of the narrow seas. In this case we have an incoming current of the less salt water on the surface, and an outflow of the heavier and salter waters below. The



physical principle underlying these currents is easily and instructively represented by Witte in the following experiment. A glass vessel, A, is filled with warm or fresh water, and another, B, with cold water or a solution of salt. The vessels are then connected by two glass siphons, one of which has a longer side-piece than the other, and both being filled with water. The longer tube must be filled with the heavier water. The circulation which now sets in through the cylinders, and which is indicated by the arrow heads, at once becomes visible, and is more clearly recognized if one of the liquids has been previously coloured.

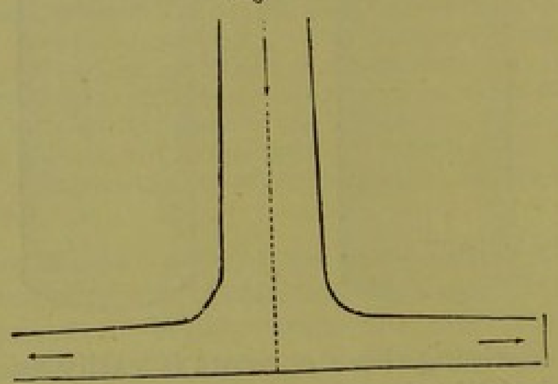
Currents in the Indian and Pacific Oceans.

We have already pointed out the theory of the necessity of an equatorial current in the open ocean; we will now go on to consider this current as it actually exists, and to examine it in detail. It is to be seen in greatest perfection of development in the Pacific Ocean, and is sometimes called the equinoctial current, because it is strongest in tropical regions. Humboldt called it the rotation current, to signify the great effect exercised upon it by the earth's rotation. This equatorial current is divided in the Pacific into several distinct and separate parts, a northern stream and a broader current flowing south from the equator. These two streams are divided by the equatorial contrary current flowing from east to west, and having its axis situated about 5° N. lat. The effect of the earth's rotation upon this current is shown by the fact that for 60° of longitude both its northern and southern branches flow almost parallel with the equator. According to Duperrey, this mighty current extends to a width of nearly three thousand miles, and its average daily speed is estimated at sixteen miles. Its depth is not yet known, but in some places the water 1,860 yards below the surface participates in its movement.

Under these circumstances the equatorial current presents itself to us as one of the greatest problems which are met with in the physical conditions of our globe. We might be tempted to doubt the existence of this contrary current, especially as its rate of speed is just the same, but in an opposite direction, as that of the equatorial current on either side. But its existence is too well established to be set aside for the sake of any theoretical difficulty with which it is attended.

Zoeppritz has recently pointed out some particulars which may tend to lead to a clearing up of some of these difficulties. The variations of form and speed to which a current, coming from an immense distance, at a uniform rate of speed, and over a given breadth, is liable when it breaks against a vertical wall, must be calculated as follows. If, for instance, the opposing wall is vertical at right angles to the axis of the current, the latter will divide

Fig. 1.



into two parts of equal width and at right angles to the axis. If the wall is of illimitable length, these two branch currents will flow in opposite directions along the wall which will then be bounded by a current, as shown in fig. 1. The boundary lines will be divided into two symmetrical halves by two degrees, which are drawn from the point where the axis of the current meets the wall at 45° from the two branches. At equal distance from the point of separation each branch is half as wide as the undivided current, and the speed of each branch at a great distance from the point of separation is the same as that of the original current at its starting-point.

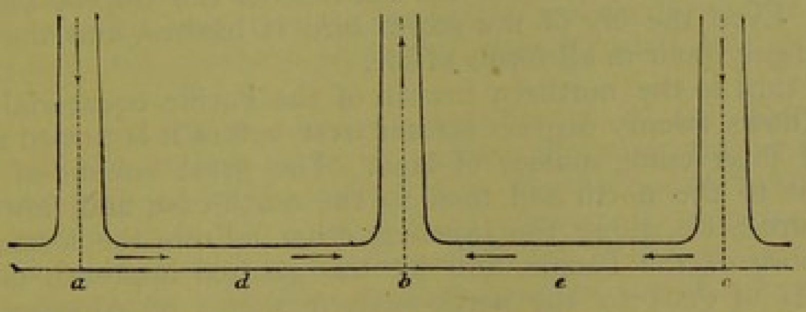
Exactly the same boundary curve is obtained if the movements above described occur at the same rate of speed and in contrary directions; that is, if two currents of equal width and speed meet along the side of a wall. They would then unite, and turn away from the wall at a right angle, forming one current, which at its greatest distance would be twice as wide as each of the meeting branches, and which would retain its original rate of speed. If a wall be struck vertically at two remote points by two currents of equal breadth and speed, the inward-flowing branches will also possess equal breadth and speed, and they will unite in the centre between the two original currents, and form a similar current, but in the opposite direction, if the distances between the points *a b c* (fig. 2) are large enough for the branches *d* and *e* to have half the breadth of the original current; an assumption which, strictly speaking, can only be realized at an immeasurable distance from the dividing points. If the primary currents are nearer together, the combined retreating stream will be created in the ordinary way, only that its width will increase at *d* and *e*, the nearer the primary currents advance towards each other. Also the diverging branches at *f* and *g* would undergo changes, and probably be strengthened.

Although the conditions of the ocean currents are far more complicated, yet it is rightly considered that the considerations we have just recorded may facilitate the comprehension of the equatorial contrary current. It cannot be denied that the supposed case presents certain analogies with the actual phenomena observed in the ocean. If the primary currents driven by the trade winds advance with uniform rapidity from a great distance, the contrary current must also flow with equal rapidity as long as it meets with no check. In the Pacific this supposition is approached by the reality, as the speed of the two equatorial currents varies from twelve to twenty-two geographical miles in twenty-four hours, while the equatorial contrary current has the rapidity of eighteen geographical miles in the same time.

The great current flows on without any considerable check through the island clusters of Polynesia, till it approaches the coasts of Asia and Australia, and the large adjacent islands. The first deviation from the original course now takes place, and that according to a law of which we shall speak more at length in the chapter on atmospheric currents.

In the northern hemisphere the currents flow with a tendency to turn in the same direction as the finger of a watch, and in the southern hemisphere with a tendency towards the opposite direction. According to this law, we first see the southern branch send out a branch flowing east from New Zealand towards the South Pole; then another branch starts for the same direction between Australia and New Zealand; the rest of the original

Fig. 2



current passes through Torres Straits, and loses its character of unity. Turning to the west coast of South America, we find that here, in obedience to the same rule, a strong current flows up at the south-west, which, as it comes from the arctic regions, brings with it floods of cold water along the coast towards the north. The only part of the ocean in which this antarctic current remains is in the waters known as the Peruvian current; the rest goes on towards the Atlantic, round the point of South America, as the current of Cape Horn.

The cold Peruvian current was first recognized by Humboldt in the autumn of 1802. Its influence upon the districts near the coasts of South America is very considerable, allaying, as it does, the burning heat of the almost rainless shores. At certain seasons of the year this cold current was found to possess a temperature of 59° Fahr., while the water outside of it rose to 82°, 83°, Fahr. At the point where the South American coast projects farthest westward, the current suddenly turns westward from the land, so that the sailor making for the north suddenly finds himself exchanging the chill waters of the current for the warmer ocean waves. The change of temperature is not the only effect of which he is conscious; for the cold current, flowing at the rate of twelve to sixteen miles a day, greatly favours the ship coasting from south to north, and is therefore much used by sailors; while the return passage from the equator to Magellan's Straits is greatly lengthened by the same adverse current, and sailing vessels which accomplished the distance in a few weeks by the aid of the current take several months to travel the same distance against the stream.

Between the Peruvian and the southern equatorial current lies the desolate region of the Southern Ocean. These waters, Maury tells us, are but rarely visited by whaling vessels. The cause of their avoidance is not known, but the fact is indisputable. In former days the white sail of a ship scarcely ever broke their monotony, and man, who strives to assert himself in every corner of the globe, left this undisturbed. Neither the practical purposes of navigation nor the highways of commerce attracted him thither. Now and then some wandering cruiser or enterprising whaler crossed the waters, but for all other seafarers the passage was neglected until the gold diggings of Australia and the guano islands of Peru suddenly caused it to become a frequented thoroughfare. Now the watery waste is crossed by all Australian vessels bound for South America, and is described in many of their log-books as a region almost entirely destitute of life in sea or sky. In the southern districts of the Pacific the ships are often followed by sea birds, which accompany them like good comrades through storm and calm for many a weary week. Even such species as the albatross and Cape pigeon, which love the stormy skies of Cape Horn and the antarctic regions, often keep by the ship till she reaches the eternal summer of the tropics. The sea birds that follow the Australian ship remain with her till she reaches the tropics, but then they disappear. Even the cry of the storm bird is hushed, and the sea, we are told, is strangely poor in all forms of life.

If we turn to the northern branch of the Pacific equatorial current, we find that it flows twenty degrees farther west before it is turned aside by the presence of intervening masses of land. The great volume of the current swerves first to the north and then to the north-east, and flows under the name of Kuro-Siwo, along the Japanese coast. From the formation of the northern shore of the Pacific, and by the gradual approach of the north-eastern parts of Asia to the north-western shores of America the warm Japanese current is forced to turn in a great curve towards California, and to descend from higher to lower latitudes. At this point the influence of the earth's rotation combined with the trade winds, which have turned aside like the current, and from the same cause, makes itself felt upon the flowing waters, which unite with the northern equatorial current south of the Tropic of Cancer, between Hawaii and the coast of Mexico; the two currents having previously separated between Formosa and the Ladrones. As a rule, the Kuro-Siwo describes half an elliptical curve in its lengthening out of the so-called North Pacific current between the Tropic of Cancer and 50 degrees N. lat. in the Pacific. The warm current contrasts, by the peculiar colour of its waters, with the irregularly flowing sea water which surrounds it. The Japanese sailors have given it the name of Kuro-Siwo, or the dark current, from the deep blue tint of its waters.

This current, we have said, separates at the Island of Formosa, from the northern equatorial current, but periodically, when the sun is north of the equator, it is increased by the monsoons of the Carolinas: the south-west monsoon of the China Sea especially influencing the force of the Kuro-Siwo.

The Japanese current is narrowest almost immediately below the Tropic of Cancer. Here it turns northward, flowing along the Island of Formosa; after which, assuming a north-easterly direction, and increasing in width, it washes the northern shores of Nipon. Part of the warm streams from Formosa pass through Broughton Straits into the Sea of Japan, flow out of it through the Straits of La Perouse, and unite with the principal current. By this course the coasts of Japan are surrounded with a belt of warm water, owing to which the January isothermal lines rise considerably, as they pass by Nipon towards the north. The presence of this warm current also accounts for the small quantity of ice found in the Japanese seas between Nipon and Corea during the winter season, while the Gulf of Pechili, lying to the west, upon the same parallel of latitude, abounds in ice at the same season.

Advancing farther northward, the Kuro-Siwo comes in contact with the cold Arctic current. The latter divides the warm stream into two parts, and their meeting-place is known by the constant presence of dense fogs resting upon the waters. The western portion of the current turns towards Behring's Straits, which it crosses at the rate of from one to three knots an hour, and flows along the American coast. Mere theoretical probabilities might incline us to predict that the current would make for this coast rather than for the Asiatic continent; and the actual fact is proved by the quantity of floating timber carried to the American coast. Berghaus, upon his large chart, traces the principal branch of the cold Kamtschatkan current, as flowing towards the Asiatic side, but this representation needs correction. Moreover, one part of the Kamtschatkan current separates at the south of the island of St. Lawrence, and turns towards the east, then to the south, and finally to the south-west, where it supplies the northern shores of the Aleutian Islands with drift-wood.

Let us now return to the principal branch of the Kuro-Siwo. In latitude 45° N., this current takes an easterly direction, and at 180 degrees west longitude is turned by the cold stream flowing out of Behring's Straits, and forced somewhat to the south. Soon afterwards, however, it recovers its northward position, and in 50 degrees N. lat., and 150 west long., flows towards the south-east. In the neighbourhood of the Kurile and Aleutian Islands, where the Japanese current comes in contact with the cold Polar streams, the latter sink beneath it, and wend their way southward as a submarine current. Along the north-western current of the Kuro-Siwo, where it is met by the cold stream issuing from the Sea of Okhotsk, the transition of one current into the other is announced by a rapid decrease of temperature to the extent of 10 or 12 degrees, and the limits at which the water begins to rise in temperature are rendered visible by surf and foam like that which is seen above sunken rocks or shallows.

Captain Belknap, during his scientific investigations in the Tuscarora expedition, has furnished the latest particulars concerning the Kuro-Siwo. He tells us that the current extends in an easterly course towards the American coast, while its northern limits reach very nearly to Vancouver Island; then turning southward it flows into the stream inaccurately termed the cold Californian current. A submarine current now sets in below it, flowing to the north-west, and reaching the surface at 50 North latitude, where it turns to the north along the coasts of British America and the neighbouring islands; then, influenced by the coast, it turns gradually to the west, attaining at Sitka Island a rapidity of one knot an hour.

One part of the water carried westward by the submarine current appears to return at 157° West longitude to the northern part of the Kuro-Siwo, and uniting with its waters, flows as a drift current along the west coast of America;

farther on, the part flowing south-west to the west of 157° West longitude, disappears as a submarine current below the Kuro-Siwo.

A rapid fall of the temperature of from 14 to 8 degrees in a few miles, during the passage of the *Ounimak* shows that the north-west coast of the Aleutian Islands is washed by the cold streams of Behring Straits, where the temperature is at times modified by the entrance of part of the westward current near the islands lying to the east.

The sea of Okhotsk, that north-west basin of the Pacific Ocean, which is sometimes called the frozen sea of the Pacific, is, like the China Sea, remarkable for various peculiarities in its system of currents. A closer examination of these currents by Von Schrenk shows that there are three principal branches sent out by the Sea of Okhotsk towards the south.

The first of these currents has its origin in the coldest part of these waters, that is to say, in the gulfs of Penjinsk and Gijinsk. It flows along the west coast of Kamtschatka, washes the shores of the Kurile Islands, and reaches the eastern coast of Jesso, where it separates in the Sangar Straits, sending out one branch towards the northern coast of Niphon, between that country and the Kuro-Siwo, and another into the Straits of Sangar, where, vanquished in its encounter with a Japanese current, it sinks below the surface.

The second current also rises in the north-east quarter of the Sea of Okhotsk, and flows along the east coast towards the Island of Saghalien, where it also comes into conflict with a warm current, and is driven below the surface. The inclement climate of Saghalien is due to the presence of this current.

The third current starts from the islands of Shantas, flows along the coast to the south-east, and presses toward the northern point of the Amoor. Here, forced below by the waters of the river, it sinks as a subaqueous current into the bed of the fresh-water stream, then passing by the west coast of Saghalien, still in a southerly direction, it crosses the Straits of Mamia-Rinso, and probably enters the north part of the Sea of Japan. Originally only a submarine current, it flows over the shallows and the shallow coast of the Saghalien Island till it reappears at length on the surface, and exerts a strong influence upon the climate and vegetation of the islands, which in comparison to those of the mainland, are inclement and stunted. But apart from these three currents, the course of which we have described, the strong winds from the north-west often drive forth from the Sea of Okhotsk great masses of water into the Amoor, and fill it in the spring and autumn with vast quantities of ice, which travel thence to the Sea of Japan; since the Amoor is not, as was once conjectured, closed to their passage by any land lying to the south. Von Schrenk has given to the third cold current of the Sea of Okhotsk the name of Amoor current, from the place where it comes into existence, and he considers that it reaches as far as Broughton Straits in the south-west of the Corea.

Through the Corea, a current directly opposed to the three we have been considering, both in direction and character, enters the Sea of Japan, and flows through it in a northward course towards the Straits of Sangar. At present it is uncertain how near this contrary current approaches to Niphon, or whether it actually washes the shores of that place. As soon as it enters the western opening of the Straits, it sends one branch through them to meet the advancing current from the Kurile Islands. The other branch continues its northerly course along the coasts of Jesso to the Straits of La Perouse, where it sends out another branch which flows through the Straits to the south part of the Sea of Okhotsk.

This latter branch bends round Cape Aniwa, the south-easterly point of Saghalien, and presses forward to Patience Bay to meet the Saghalien current. The remainder of the warm northward current, which is now much diminished, is finally lost along the west coast of Saghalien towards the north. A highly beneficial effect is exercised by this current upon the climate of the west coast of Niphon, Jesso, and south Saghalien, and even upon part of the eastern coast of the latter island, bringing to them, as it does, the warm waters of the South Pacific. Von Schrenk has called this current Tsusima, from the islands of that name which are situated near the southern entrance to the Sea of Japan and in the central point of the current's course.

Some remarkable currents are noticed in the China Sea, that great basin lying between farther India, the Sunda Islands, the Philippines, and the Island of Formosa. Over its waters from October to April there is an almost uninterrupted north wind blowing, which is followed from May to September by a south wind. Each wind produces a corresponding current which changes in direction with the change of wind. Wagner has pointed out that the north-east current produced by the south-west wind is not so constant as the south-west current produced by the contrary wind. In the open sea, he says, the north-easterly current is seldom strong, in calms it becomes almost imperceptible, or flows in every possible direction. It is the strongest near the coasts, and above the shallows, and round the projecting capes and islands. The north-east current shows itself in May in the southern parts of the sea between Singapore and Pulo Condore, flows during the whole time of the monsoon, and varies in speed from three-quarters to one and a half geographical mile an hour. Coming from the south, it first assumes a north-easterly direction on the coasts of Cambodia and Cochin China. From the mouth of the river Cambodia it turns east-north-east, and has at first a speed of about one geographical mile an hour; but rapidly quickening its advance, it reaches near Cape Padaran the rate of from two to three geographical miles an hour.

Owing to the change of course imparted to the waters in the Gulf of Cambodia, a division occurs in the current. The principal stream continues its way eastward into the open sea, where it gradually recovers its main direction toward the north-east; the northern part turns sharply to the north round Cape Padaran, while the southern branch flows east-south-east through the islands by Pulo Sapata, till it reaches the wide shallows lying on the eastern side of the navigable water. Along these shallows it flows south-east and south, so that no current, or only one in a south-westerly direction, is found during the south-east monsoon in the waters of the triangle lying between Vanguard Bank, Rifleman Bank, and North Natunas. The current reaches its maximum speed at Cape Padaran, after which point its rate of advance is again reduced to one geographical mile and a half.

In the month of June the north-east current extends over the whole China Sea. The branch flowing round Cape Padaran advances in a north-east course through the Straits of Formosa, and enters the Pacific between that island and Luzon. The branch which diverges at Cape Padaran flows northward along the coast, and then divides, sending one arm into the Gulf of Tonquin, and another between Hainan and Paracels, till it regains its course to the east-north-east on the south coast of China, and unites with the main current flowing from the open sea, and flows as one stream through the Straits of Formosa north-north-east.

The main branch of the great current flows uninterruptedly toward the east or east-south-east, assuming the latter course especially along the shallows of North Danger as far as Vanguard Bank. Between the shallows and the coast of Borneo there is very little perceptible current, and at times the slight streams flow there toward the south-west. What we have just said may be taken generally for the rule as regards these currents, but it is a rule subject to many exceptions. The south-west monsoon is by no means so constant and regular as the opposite wind, and every irregularity is naturally reflected in the current which it produces.

The north-east current ceases in September, and the presence of the contrary wind soon makes itself felt, as farther north the north-east monsoon has already begun in the latter half of September to agitate the waters. At the beginning of October a south-west current is found all over the China Sea, reaching its greatest strength in December and January. Coming from the north, it flows through the Straits of Formosa in a south-westerly course into the China Sea. At Breaker Point it sends off a branch west-south-west, which flows by the south coast of China, near Hainan and to the west of the Paracels; then, reaching the coast of Cochin China, unites with the main stream which has held on its course through the Channel of Formosa, and flows over the shallows of the Pratus, through the open sea east of the Paracels, uniting again at Cape Varela. From Breaker Point this current attains a considerable degree of velocity, especially when the monsoon blows with violence through the Straits of Formosa. A westerly deviation sets in at Cape Padaran. The masses of water advancing from the north and north-east meet here with a check which causes them to swerve from their course. The main stream is turned southward by the land between Cape Varela and Padaran, and forms between Pulo Sapata and the shallows of Palawan a whirlpool, which extends for 200 geographical miles in diameter, and moves in a contrary direction to the course of the hands of a clock. At Padaran, to the south of Cape Varela, the current reaches its maximum velocity of 60 geographical miles a day. Southward of Pulo Sapal, it decreases in strength, and flows first toward the south-east and then east and north-east. Along the shallows of Vanguard Bank, as far as North Danger, an east-north-easterly current is generally found running at the rate of from three-quarters to two geographical miles an hour. One arm of the current flows from Cape Padaran in a west-south-westerly direction along the coast, and unites south of Pulo Condore and Pulo Oby with the main stream, which can be traced to the line and through the straits.

The equatorial current of the Indian Ocean is generally found at 10° S. lat., while a contrary current makes its presence felt at the equator itself. The latter is divided into two branches by the great island of Madagascar, the eastern branch flowing southward, while the other and more powerful stream, known as the Mozambique current, flows through the straits, the name of which it bears, with a daily speed of from five to six geographical miles, and turns southwards towards the Crozet Islands. It was formerly believed that this warm current held its course close to the African coast, following every bend of the land, and entering the Atlantic by Cape Horn. Such a course would contradict every rule by which the flow of a current is determined, and the only support brought forward for the belief was the fact that a powerful warm current, known as that of the Agulhas, does actually flow in that place. More accurate researches made by the *Challenger* show that this strong warm current of the Agulhas, which affects the temperature of watery strata 874 yards below the surface, and has a decided influence upon the climate of the Cape, does not enter the Atlantic, but remains in the sea to the south of the Cape of Good Hope. There it meets with a cold current flowing from the Atlantic, and is forced eastward, after which the two streams gradually unite. The limits of these two contrasting currents are by no means clearly defined, but are subject to great irregularities, principally owing to the frequent changes of the winds.

The first sign of the nearness of the Agulhas current was perceived by the *Challenger* 380 geographical miles west of the Cape, where the temperature of the surface of the sea was found to be about 60°, or nearly two degrees higher than on the preceding or following days. Its speed northwards amounted to twenty-five geographical miles daily, but this high rate must be partly ascribed to the prevalence of south winds. The true Agulhas current, or rather that northern branch of it which follows the west coast of the Cape, was not perceived until within twenty-one geographical miles of the land, and showed a rise of temperature at the surface of the water from 58° to 59°. The serial temperature observed within the next five geographical miles nearer the land showed that the influence of the Agulhas surface current extended to a depth of 180 yards, the temperature at that depth being two degrees higher than further seawards.

An extensive and long-continued series of observations must be made respecting the causes which check and turn aside the Agulhas current, before any definite conclusions concerning them can be reached. The observations of the *Challenger* expedition seem to indicate that the wide, slow South Atlantic drift current is driven eastward by the continuous pressure of the west wind, its waters being massed upward on the west coast of Africa, and the sea level being raised sufficiently to bar the further advance of the Agulhas current, which is either turned aside or almost entirely absorbed by the cold drift stream. The smaller branch of the Agulhas current, which is driven northward round the Cape during the prevalence of the south winds, mingles with the cold waters of the surface current, which also sends on an outrunner to the north, skirting the Agulhas current on this as well as on the African coast.

The meeting and combination of two such opposite currents cannot, of course, take place without giving rise to great changes of temperature. Thus the warm current seldom presses further than Table Bay, where the water is considerably colder that in Simon's Bay.

THE CURRENTS OF THE ATLANTIC.

The Atlantic currents present a distinct and complicated system of their own, which is only slightly connected with the currents of the Pacific, inasmuch as the Cape Horn current enters the Atlantic Ocean round the Cape from which it takes its name. Athanasius Kircher, two hundred years ago, was the first to bring forward a chart of the Atlantic currents. We find the equatorial current traced upon this chart, with its division into two branches, a north-westerly and a south-westerly branch, at the projecting point of Brazil. Both these branches exist in fact, but the equatorial current does not run parallel to the line; on the contrary, it intersects it at a rather sharp angle. According to the researches made by Scott, the equatorial current begins on the coast of Africa, and extends to 3° N. lat. In the first meridian it flows with a speed of from twelve to sixteen geographical miles. It keeps up along its northern limit of 3° N. lat. a westerly course of more than 1,320 geographical miles, but its rate of speed varies from twenty-four to twelve geographical miles a day. Near the coast of Brazil it receives a north-westerly impulsion, and at a distance of about 640 geographical miles from the coast the course of the current is visibly affected by the land. On the coast of Brazil it advances at the rate of from fifty-seven geographical miles a day, and on the coast of Guinea from twenty-eight to twenty geographical miles. At 50° W. long. it comes into contact with the western drift current.

This westerly current forces its way through the West Indian Islands to the Caribbean Sea, to the north of Trinidad, at the rate of from thirty-two to forty geographical miles. On the coast of Central America it swerves to the north-west, flows through the Straits of Yucatan with an average speed of twenty-eight geographical miles, and enters the Gulf of Mexico, where it re-enters the Atlantic between Florida and Cuba as the Gulf Stream. A considerable part of the western current is, however, left outside the Caribbean Sea and the Gulf of Mexico, turning eastward from the West Indian Islands towards the coast of North America, and becoming absorbed in the warmer waters of the Gulf Stream proper.

It must not be overlooked, that the direction, situation, and speed of the several currents, as stated in this chapter, only represent average valuations; the actual currents, as has been indisputably proved by recent observations, not only vary periodically from month to month, but even alter their position, being somewhat differently placed in different years.

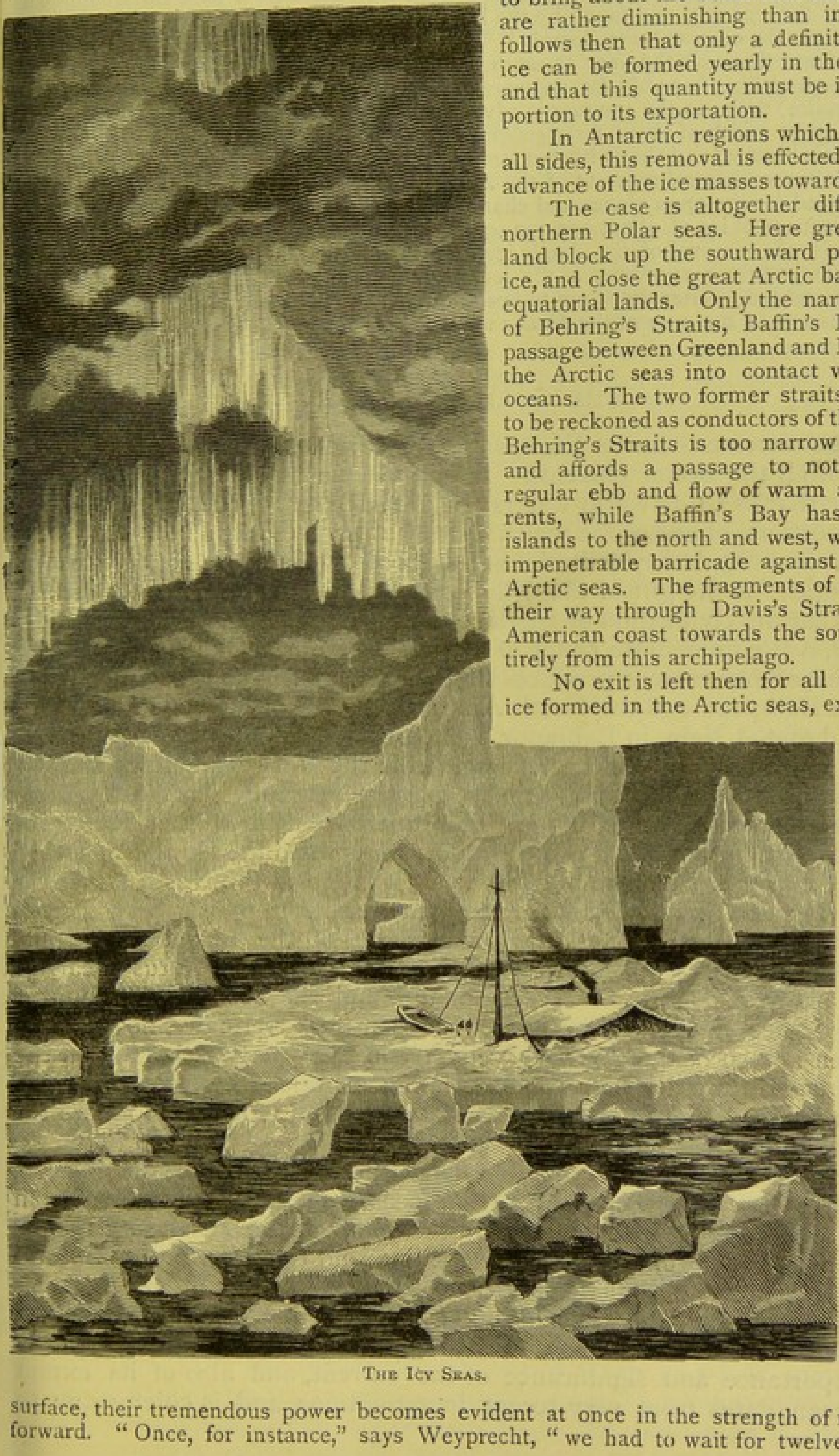
In the angle formed by the equatorial current, the western drift stream and the African coast, a powerful current known as the Guinea current flows in an easterly course. It was first traced with a near approach to accuracy by Maury, who, however, carried it southward across the line to beyond the Cape; a course which bids defiance to every analogy with the direction of all other currents. Only northward-flowing currents are found along the western coasts of the southern hemisphere, and as a rule the ocean currents carry no water from one hemisphere to another, their circulation being restricted to their respective hemispheres. The anomalous course assumed by the Guinea current, according to Maury's supposition, has no foundation in fact, as has been shown by Findlay. More recently this current has been subjected to closer investigation; and Krümmel, having gone through all the evidence so collected, has arrived at the following results. A yearly change takes place in the extent of the Guinea current; it reaches its greatest development in August and September, in which months it is perceptible beyond 40° W. long.; its most restricted course is noticed in March, when it only begins at 25° W. long. The Guinea current is a few degrees warmer than the equatorial current; indeed, it rivals in warmth the hottest parts of the Gulf Stream. These particulars are noticeably reflected in the climatic character of the four islands which lie in the Gulf of Guinea. The southern island remains the whole year through in the cold waters of the current flowing westward from the antarctic regions towards the equator; the two northern islands are washed by the warm streams of the eastward-flowing Guinea current, as it advances northward; while the centre island of Saint Thomas feels alternately the effects of each current, as at the northern solstice the south current presses northward, and at the southern the north current presses southward, each bringing with it a change of temperature.

As we intend to speak of the Gulf Stream more at length in a separate section, we have not felt bound to notice in our present review of the Alantic currents, the Arctic stream which flows southward along the American coast. We shall see later on how this cold current appears in its conflict with the warm waters of the Gulf Stream, and for the present we will only notice that it carries great masses of water across from the eastern parts of the north Asiatic coast to the western shores of North America. As far back as the year 1852, Petermann gave it as his belief that driftwood was carried down the Siberian rivers, not only to Spitzbergen, but to Greenland. Lamont, who encountered great quantities of this floating timber in the year 1859 upon the south-east coast of Spitzbergen, recognized it decidedly as pine wood coming from Siberia. Numerous specimens of this driftwood were brought back by the Swedish expedition to Spitzbergen, and were subjected to close examination by Agardh. The result proved beyond a doubt that not one single specimen belonged to any other species than the Siberian larch, a tree which grows in great quantities on the plains of European and Asiatic Russia. It was thus established that the driftwood is not carried from warmer countries by the Gulf Stream to the Arctic coasts, but that it is floated down the Arctic streams from Siberia. The establishment of this fact led to further conclusions. "As Columbus," says Peschel, "divined the existence of a western land by the presence of foreign timber drifted on the shores of the Canaries, we may conclude with certainty, from the appearance of Siberian forest trees upon the coast of Spitzbergen, that the Siberian Arctic sea is open. The waters round the north of Siberia and the east of Spitzbergen must be free to admit the passage of the driftwood sent down the rivers of Yenisei and Lena, and to transmit it on to the coast of Spitzbergen."

The Arctic currents are strongest in summer, not in winter. In the cold winter months the frozen ocean is at rest, and has drawn in its icy streams. The shores of Newfoundland are wholly free from drift ice in the winter, while in the summer months the seas are full of it, and present the appearance of an Arctic Ocean. The sailors fear to come within a thousand yards of the masses of ice, and always endeavour to keep to leeward of them. The difference of temperature between the icebergs and the warm currents of the sea water causes clouds of mist to rise and enwrap them in its folds, but the weird glare reflected from their gleaming whiteness combines with the sudden fall of the temperature to betray their presence. Unfortunately it is often too late to escape the danger when these warnings have been perceived by the seafarer, and hundreds of good ships have gone down with all hands, broken by the shock of the ice giants, to perish in the cold Arctic floods. At other times whole fleets of icebergs are met with in fair weather, and the sailor has to exercise the greatest care and skill in avoiding their course for days together. It was thus that in the year 1834 the English brig *Anna* was overtaken by icebergs near Cape Race, and enclosed by the threatening mass of crags and obelisks for twenty-nine days, when she at last succeeded in escaping from them, and gaining the open sea. A sudden death awaits the fantastic monsters of the ice world in the waves of the Gulf Stream, and it is very seldom that one is found straying farther south than 40° north latitude.

All the ice which is found floating in the Arctic seas is subject, as far as its movement is concerned, to the same laws as the air and water which work upon it, and consequently its chief motive powers are the ocean and the atmospheric currents. The influence of the latter, however, is for the most part only local and temporary, and the ocean currents must be regarded as the true regulators of the iceberg in all the polar regions.

These currents are absolutely necessary for the preservation of the due proportions of temperature upon our globe. In the Arctic regions, where the yearly average temperature is below freezing point, more ice is created annually than the summer months can get rid of by melting. Unless then the cold currents aided in carrying some of the ice downward, while the warm currents flowed upward to dissolve other fragments, we should see the poles advancing toward a state of congelation. If only one more ice field were produced every winter than the summer could carry away, the influences upon the earth's climate even in historic times would be most disastrous. This, however, is not the case certain reasons tend to bring about the belief that the realms of ice are rather diminishing than increasing. It follows then that only a definite quantity of ice can be formed yearly in the frozen seas, and that this quantity must be in a fixed proportion to its exportation.



The Icy Seas.

In Antarctic regions which are open on all sides, this removal is effected by a uniform advance of the ice masses towards the equator.

The case is altogether different in the northern Polar seas. Here great masses of land block up the southward passage of the ice, and close the great Arctic basins from the equatorial lands. Only the narrow openings of Behring's Straits, Baffin's Bay, and the passage between Greenland and Norway, bring the Arctic seas into contact with the open oceans. The two former straits are scarcely to be reckoned as conductors of the ice masses. Behring's Straits is too narrow and shallow, and affords a passage to nothing but the regular ebb and flow of warm and cold currents, while Baffin's Bay has a chaos of islands to the north and west, which form an impenetrable barricade against the ice of the Arctic seas. The fragments of ice which win their way through Davis's Straits, along the American coast towards the south, come entirely from this archipelago.

No exit is left then for all the masses of ice formed in the Arctic seas, except the passage between Greenland and Norway, and here we find a wonderful system of currents developed for the purpose. The sea in this place is very open and of great extent, so that the course of these currents is particularly gentle and regular; but whenever any obstacle is presented to their advance by the bed of the stream or any other cause, above or below the surface, their tremendous power becomes evident at once in the strength of resistance put forward. "Once, for instance," says Weyprecht, "we had to wait for twelve weary days, thwarted and tossed about at the south cape of Spitzbergen, vainly endeavouring to reach the Stor fiord, and at Hope Island the force of the current obliged us to wind up the anchors, which were utterly unable to protect us from its violence. I took observations as to the speed of the current, and found by the log that it was running tw lve miles an hour. The same thing is the case at Nova Zembla."

A cold stream flows all the year through along the east coast of Greenland from the Arctic Sea, which reaches in 75° N. lat. an average speed of about ten miles (or two and a half geographical miles) daily; in the summer it advances rather further south than in the winter, and has an average width of about forty geographical miles. This current is covered with ice over its whole extent, and that with the heavy pack ice, whose home and cradle must be found in the unknown central recesses of the Arctic seas. If about one-third of its surface extent is deducted for the open places and channels, it will yet be found to carry down every year a compact mass of ice of about 200,000 square geographical miles. This current is the great channel for the removal of the Arctic ice toward the south, and must be considered as the chief regulator of the proportions of the ice masses in the Arctic basins. Its course has been accurately traced in later times, not to speak of many earlier observations upon it in the unfortunate passage of the crew of the *Hansa* upon an iceberg.

The Gulf Stream.

The Gulf Stream is for us Europeans the most important and the most interesting of all the ocean currents. It is a true source of life for civilized Europe; for, thanks to its warm waters, the development of culture is rendered possible in portions of our globe which are situated at the same distance from the North Pole as the dreary solitudes of the shores of Hudson's Bay. "Egypt," says Herodotus, "is the gift of the Nile," and Englishmen may assert with no less justice that the civilization of England, and her position among the nations of the world, is the immediate result of the presence of the Gulf Stream. The course of this mighty current produces the most wonderful contrasts of climate between the European and the North American shores of the Atlantic Ocean. Thus we find that at Nain, in Labrador, there exists in January an average temperature of more than 14° below freezing, while the Norwegian town Bergen, which is nearer to the Pole by fully fifty geographical miles, has in the same month an average temperature of 35°. This difference is altogether due to the Gulf Stream, which flows like a protecting rampart round the European coasts, while the icy currents from the north are thrust aside to the North American continent. The Arctic inhabitants of the seas are shut in by the Gulf Stream as by the wall of a fortress, and the great whales of the frozen seas would shrink back from its waters as from a sea of fire. While the walrus is carried by the drift ice to the shores of Newfoundland, and the polar bear is hunted in the same degree of latitude as that of the centre of Germany, no instance has ever been known of that "tiger of the Arctic seas" having landed on the coasts of Great Britain. Even Scandinavia has no tales to tell of visits paid by the polar bears, while the coasts of Spitzbergen and Nova Zembla are the favourite haunts of those animals.

If it were not for the insurmountable barrier presented by the Gulf Stream, it is not easy to say why the Scandinavian coasts should be preserved from their incursions. The position of the Gulf Stream in the Atlantic Ocean is itself affected by the formation of the coast line and the distribution of land and water. It would be a mistaken idea to suppose that the important influence exercised by the Gulf Stream upon the present state of the civilized world was known in former times. On the contrary, the recognition of the supreme importance and significance of the current, and also of its extent over the ocean, dates from very recent investigations, and is chiefly due to Petermann.

The Spanish voyager, Ponce de Leon and de Alaminas, were the first who in the year 1513 discovered some portion of the Gulf Stream. The latter soon perceived the advantage offered by the current in shortening the passage from America to Europe; and so great is the influence of the Gulf Stream in the uniting of our continent with the New World, that it may be said to have played a most important part in the rapid development of American civilization. If this current had not existed, Columbus could not have brought forward many of his weightiest arguments in favour of the western lands awaiting his discovery. As it was, however, and owing to the circular course affected by the currents of the warm streams in the North Atlantic Ocean, there had been repeated instances of foreign driftwood, trunks of unknown trees, nay, even corpses of strange-looking human beings, having been carried on to the shores of the Azores. Columbus had also heard from the lips of residents on these islands, that travellers sailing westward had fallen in with boats manned by crews of outlandish appearance. Of course these puzzling strangers need not have been the native tribes of North America; they were, in all probability, Greenlanders, who, as a matter of fact, are known to have appeared on the coast of Europe, and who could only have arrived there by means of the north-west wind and the Gulf Stream. As far back as Pliny we hear of dark-skinned men who were given as a present to Metellus Celer, when the latter was proconsul of Gaul. We hear also of so-called "Indians" who landed on the west German coast in the days of Barbarossa. Humboldt tells us that, according to a narrative of Cardinal Beneko, in the year 1508, a little boat containing seven men of small stature and foreign appearance was captured near the English coast by a French ship. No one could understand the language of these people. They were clothed in the skins of fish sewn together. They ate raw meat and drank blood like wine. Six of these men died on the voyage; the seventh, a young man, was presented to the King of France, who was then in Orleans. The description of the appearance and demeanour of these people exactly answers to the look and manner of Esquimaux. The waters of the Gulf Stream carry down numerous specimens of American plants to European islands. The fruit of the cocoa palm is frequently found on the shores of Iceland, and the quantity of timber carried to the Faroe Islands is so considerable that it is used extensively for building purposes. Very similar benefits are conferred by the Kuro-Siwo, in the North Pacific Ocean, upon the inhabitants of the Aleutian islands. No trees are found growing within these islands, and the natives are entirely dependent upon the driftwood for the building of their boats and their household furniture.

The Gulf Stream first took up the prominent position in European attention which it now holds in the year 1775, when Franklin found that by merely dipping a thermometer into the waves of the Atlantic Ocean he was able to prove whether or no the ship was sailing in the current. This was a fact of the greatest significance for transatlantic navigation; since the propelling power of the stream is of the utmost importance in the passage from America to Europe, and the sailor travelling westward does his utmost to avoid the stream, which now opposes and retards his passage. And apart from this consideration, the Gulf Stream has gained with justice an evil reputation from the frequent storms, fogs, and tempests which prevail within its waters. In winter its presence is made known to a considerable distance by these phenomena, which are occasioned by the difference of temperature between its warm waters and the cooler waves of the surrounding seas, so that the marine Gulf Stream creates above itself a kind of atmospheric Gulf Stream, of which, however, we shall speak more at length in another chapter.

The cradle of the Gulf Stream, or its source, if we may so call it, lies in the Gulf of Florida, and the speed of the current has an average rate of one geographical mile an hour; indeed, in the narrow straits of Bemina, it flows at the rate of twelve miles an hour. The current at this place is ninety-six geographical miles broad, and the high rate of speed is only local. The depth of the stream is never greater than 382 yards. The mass of water thus sent out from Florida is estimated at about forty-three million cubic yards a second. To give some idea of this quantity, we may add that it is from sixty to eighty times greater than that sent by all the rivers of the globe into the sea at one moment. The mechanical force of this current is so great that Maury has calculated that it is sufficient to propel a load of 90,000 million tons up an inclined plane of three inches in a mile at the rate of twelve miles an hour, not taking into account the resistance offered to its advance by the

NATIVE OF THE ALEUTIAN ISLANDS GATHERING DRIFTWOOD.

friction encountered. The Gulf Stream never reaches the bottom of the sea, but rests all along its wide course from beginning to end upon a bed of cold water which has an average depth of several thousand yards. The current has carved out, as it were, its passage through this bed, altering it, however, periodically in the course of the year; to use Maury's expression, it sways to and fro like an immense scarf or streamer in the Atlantic Ocean. We shall have more to say later on concerning the peculiarities of temperature found in this current; for the present we will only speak of the amount of warmth which it carries on its beneficent path. This amount, according to Croil, is more than that which is received upon a surface of 3,000,000 square miles, from the sun at the equator. The same authority tells us that the heat of this current is more than the collective heat thrown out by all the other warm atmospheric currents which blow from the equator north and south. When we take into consideration the enormous stores of heat with which the Gulf Stream is provided, and which it distributes to the countries near which it passes, we cannot agree with the celebrated English scientist, Findlay, when he asserts that the great current is wholly incapable of reaching the European coasts, and incapable of exerting a perceptible influence upon their climate. Petermann combats this view with great ability, and shows that the Gulf Stream is the initial or principal source of all movement in the waters of the North Atlantic, and that, too, in all seasons of the year. This assertion is borne out by the testimony of Maury's thermal charts. Other authorities, however, have expressed themselves against the idea that the Gulf Stream has an influence upon the climate of the European continent. Blunt states that the Gulf Stream comes to an end in 40° W. long. from Greenwich, and that beyond that degree only the ordinary movements of the Atlantic are found, and produce their respective effects upon the climate of the coasts near which they exist. But in answer to these assertions, Petermann, by an exhaustive reference to all the mass of evidence by experiment and investigation which is now collected, proves the great and real influence of the mighty current. His charts show that, far from finding an end in mid-ocean, the Gulf Stream rolls its warmth-giving waters far beyond the north coast of Europe, and is even then strong enough to be readily discernible. For it must not be forgotten that the Gulf of Florida is not by any means the only channel which supplies the waters of the Gulf Stream. It is indeed only the source of those waters which are afterwards reinforced by that great branch of the equatorial current which flows along the Antilles. Above this cooler stratum the hot waves of the Gulf Stream flow as an upper stratum, which probably never exceeds 218 yards.

If we examine Petermann's charts more closely, we shall find on the chart for the month of July the true centre and heart of the Gulf Stream between the parallels of 35 and 40 degrees N. lat., looking like a stream running in two branches towards the south-west of Europe, and reaching to 43 degrees West long. The temperature of the water at the centre is 83° 5′ Fahr., and at the extreme ends of the branches 74° 5′ Fahr. The very direction and situation of the hot stream show whence the waters come; it is the Gulf of Florida which sends them on their way.

The current rushes up northward till it reaches Newfoundland, where it dashes itself against the coast as against an opposing wall, and flows side by side with the cold Arctic current which wends its way southward. The fall of the temperature in the short distance between the Gulf Stream and the coasts of Nova Scotia and Newfoundland is consequently very great, both in summer and winter; amounting in the month of July to about 27° Fahr. in 323 miles, and in January to 45° Fahr. within the same distance.

At Newfoundland the Gulf Stream comes into violent collision with the Arctic current from Labrador, which, like a great wedge, attacks it at a right angle, and penetrates its waters. But instead of being annihilated by the encounter, as Findlay maintained, the Gulf Stream comes off the conqueror in the strife between the hot and cold forces. In the south-east course of the polar wedge, which is most sharply defined in July, gigantic icebergs and great masses of arctic ice from the north come down every spring, from February to July, but especially in April and May, and have been observed as far as the same latitude as Gibraltar and Malta, and generally on the 50th meridian; that is, in the very centre and heart of the Gulf Stream, in the heated waves of which the great icy masses absolutely explode, and disappear with almost fabulous rapidity. The Gulf Stream meanwhile suffers scarcely any essential disturbance, either in its course or temperature, by the presence of these intruders, but turns away sharply towards the north on the east coast of Newfoundland. In January, the influence of the Arctic current on the curves of the isothermal lines of the ocean is even slighter than in July.

The polar streams bring as their New Year's gifts to the coast of Newfoundland, walruses and polar bears, in latitudes which correspond to those of Paris, Cherbourg, and Brest, at the very time when in these places the vegetable world, waking from its winter sleep, grows green and blossoms, and the woods re-echo with the songs of nightingales. About this time, as the July chart shows, the sea's isothermal line intersects from 6° S. lat. to over 50° N. lat.; while the northward-flowing Gulf Stream, 427 miles to the east, has still a temperature of 68° Fahr. It continues its passage in two convex curves, and extending over about 30 degrees of longitude northwards towards Iceland. In January, the sixth isothermal line extends at Newfoundland as far as 42° N. lat., and follows the eastern coast of the United States to 37° N. lat., and about as far as Chesapeake Bay. The two convex curves of the Gulf Stream, sent out as it advances northward, are less marked than in July, and in 50° N. lat. only appear as one principal curve in the isothermal line of 54° Fahr. In about this latitude a branch of the Gulf Stream starts north-north-west for Baffin's Bay, along the west coast of Greenland, and has been traced as far as Smith's Sound.

While during the month of January, and at 50° N. lat., the Gulf Stream has still a temperature of 54° Fahr., the thermometers in Prague or Ratisbon in the same latitude stand at zero, and even lower still at times. In July, the tenth isothermal line goes towards Iceland and the Faroe Islands as far as 61° N. lat. Here the Gulf Stream and the Arctic current meet for the second time, and again the latter strives to bar its enemy's passage, and effect its destruction.

The serial temperature observations made by Admiral Irminger, in the summer months of the year, show not only that a branch of the Gulf Stream passes up the west coast of Iceland toward the north, but also that the same branch flows eastward along the whole northern coast, and does not encounter the Arctic current, setting in from the north, till it has reached the north-eastern side of the island. Irminger only records the temperature of the northern coast in the months of May, June, July, and August, when it is always found higher than the temperature of the east coast. If we confine our observations to July, we find the temperatures on the north coast to be from 40°, 42°, to 44°, while on the east coast, at a distance of only 6 degrees long., they are noted as 37° to 39°. According to the observations taken by Irminger and Lord Dufferin, the Gulf Stream predominates in July along the west and north coasts of Iceland, and the Arctic current flowing from the north in the direction of Jan Mayen, prevails along the east and south coasts.

Between Iceland and the Faroe Islands, the hot and cold currents fight for the mastery, and the result of their struggle is a curiously striped sea, intersected by the two rival streams, as described by Lord Dufferin in his passage from Stornaway to Rejkiavik, in the year 1856, and confirmed by De Wallich in the *Bulldog* expedition of 1860. The map in this work gives a good idea of the proportions of the two currents. Irminger's observations of the sea's surface and temperatures in this place point out the existence of the hot and cold streams, now side by side, now one above the other, as clearly as Wallich's researches as to the construction of the sea's bottom. The latter writer found there volcanic stones evidently owing their origin to Jan Mayen, and in other places ophiocamæ from two to five inches long, which could only have been brought there by the warm Gulf Stream. Another sign of the conflict is that the drift ice reaches farther south than anywhere else on the east of Iceland. In the year 1822, Scoresby found great masses of heavy ice in 64° 30″ N. lat.; 7° W. long., and single fragments as far as 63° 40′ N. lat., 8° W. long. Still farther south, the same thing was observed by Sir James Ross; namely, in 61° N. lat., 6° W. long., to the south-east of the Faroe Islands.

The sea's temperature appears to be lowered at the Faroe Islands, and as far as the Shetland and Orkney Islands. The isothermal line shows a striking concavity from Jan Mayen to the North Sea, such as can only be accounted for by the presence of a cold Arctic current. Rejkiavik and Hykisholva (65° 4′ N. lat.) have a sea temperature of 48° and 45° in July, while Thorshaven in 62° 2′ N. lat., has only 44°. Now and then, in consequence of this lowering of the temperature, the air over the whole extent of the Shetland Islands is considerably affected, even as far as the coasts of the North Sea, as, for instance, in July, 1867, when it appeared 4 degrees lower than the normal temperature in the Shetland Islands, Scotland, and as far as the south of England.

But even here the Gulf Stream comes forth victorious, as in the conflict near Newfoundland. We are able by many direct observations to trace its further course in summer as far as Spitzbergen, Nova Zembla, and 80° N. lat. For the winter we have few observations in the open seas, but we know its influence as well as in summer, partly by meterological records, and partly by many climatic phenomena observed on the coasts by which it flows.

The mild winter of the British Isles is well known. The average temperature in London during the month of January is 36° Fahr., in Edinburgh the same, and in Dublin 37° 5′. The farther we advance from east to west, or south to north, that is, within the limits of the Gulf Stream, the higher the temperature rises. In the Shetland Islands, at a distance of 630 miles north of London, the temperature of the sea is 44° Fahr. in January, and of the air 39°.

This last fact proves that it is no mere surface current which produces these effects, for in that case the air would be warmer than the sea. It is the warm ocean current that tempers the air, and not the air that warms the sea. The greatest cold registered in London amounts only to 4° below zero; in Penzance, on the west coast, 24° Fahr.; in the Orkney Islands, 18° Fahr.; and in Bressay, on the Shetland Islands, 16° Fahr. In Madrid a temperature of 14° Fahr. has been recorded, and in Algiers, which provides Europe with cauliflowers in January, 27° 5′ Fahr. On the morning of the 8th of February, 1870, the temperature at Ratisbon was found to be 24 degrees below freezing point, while to the north-west, at Breslau, it was only 13 degrees below; at Berlin, at zero; at Kiel, 12° Fahr.; and at Christiansand, on the south coast of Norway, 8 degrees; north of Ratisbon, at 31° Fahr. Such a high temperature would be impossible in Norway, and the winds would not be able to carry it thither, if they did not borrow their warmth from the warm Gulf Stream.

It is the Gulf Stream, moreover, that protects Iceland from the terrible cold of the winter time which prevails in the portions of Greenland which lie in the same latitude. The greatest cold observed at Rejkiavik for thirteen years is only 27° Fahr. No wonder that it is so, says Petermann in his defence of the Gulf Stream, for the warm current provides the country with heat and life; its average temperature, even in January, is 34.5, and the lowest temperature recorded in twenty years was only 28° Fahr.

While Labrador is a wretched, desolate region, where, to use the words of its first discoverers, "nothing is to be got," agriculture is carried on busily and with success in Norway, which is from ten to fifteen degrees nearer the pole. Wheat is grown as far as Inderoë, lat. 64° north, barley as far as Alten, lat. 70°. The sowing takes place generally between the 20th and 25th of June; and in the short space of eight weeks, to the 20th and 30th of August, there are on an average six or seven harvests. The potato yields on an average seven or eight crops, and in good years has yielded as many as fifteen: it thrives as far east as the Russian boundary. Very good broccoli can be had even in less favourable years at Alten, 70° N. lat. By the Arctic current, as was found in the Franklin expedition, in latitude 60-70°, there are seen on the one side nothing but the wretched snow huts of the Esquimaux, and on the other (lat. 70°) the flourishing, busy little town of Hammerfest, where the

A December Scene in Germany

greatest cold recorded in winter once reached 270 degrees, but as a rule never sinks below 22 degrees.

While Germany is often enduring in the winter season more than 24° below freezing point, rich harvests are being reaped in Norway just below the Arctic circle; harvests found, not indeed in the fields, but in the warm floods of the Gulf Streams near Aasvaer; for on the 10th of December countless shoals of herrings make their appearance, and from that time until the first days of January 10,000 men are busily engaged in fishing. They catch on an average 200,000 tons of herrings, which represent a value of £218,020. If we turn northward from the European coast, we reach Bear's Island and Nova Zembla—we are now about to speak only of the western coast of this dual island. In order to show the influence of the Gulf Stream, and its existence between Bear's Island and Nova Zembla, Petermann has drawn up a table of the average monthly temperatures of Bear's Island, Nova Zembla, and numerous other places.

The observations on Bear's Island were taken three times a day, from the 6th of August, 1865, to the 19th of June, 1866. But as far back as the year 1824 Norwegian walrus hunters used frequently to winter at Bear's Island, and have left a record of the weather during the year.

"Until the middle of November the weather remained mild, the snow that fell on one day melting on the next. We had rain in the Christmas week, and caught about seventy walrus by moonlight and the aurora borealis. The weather remained mild until February, so that work could be done out of doors, and the sea was relatively clear from ice, so much so, indeed, that the polar bears did not appear upon the island till April, when the cold reached its maximum, and the sea was covered with solid ice. The ice comes principally from Siberia in the north-east; but, according to the records, the north-east wind had not prevailed during all the winter, so that but little ice had reached the island. To all appearance the Gulf Stream retained its predominance during the winter, and the winds which swept the

HERRING FISHING NEAR THE ARCTIC CIRCLE.

island in this direction brought rain even in the Christmas week. But after the sun had reappeared above the central Arctic regions, and the temperature gradually increased, the ice broke away from its Siberian birthplace, and from the other frozen coasts, and set out upon its southward wanderings. The greater part of the ice which reached Bear's Island did not arrive there until June and the beginning of July, and this is the time at which, with great regularity, the Siberian coasts are freed from ice every year. Until this time all the winds blew cold from the north-east, because they had crossed the frozen sea, but at other times a north-east wind brought mild weather."

From the calendars of the year 1865 to 1866 the island could be rowed round in boats until the end of October; on the 6th of November no ice was in sight, and in the following days the island and the surrounding sea were comparatively clear; that is, from the 16th—19th of December; 30th November; 4th December; 7th—10th of December; 31st December to 7th January; 3rd—5th of February; 10th—24th of February; 2nd of March and 23rd of March.

While the atmospheric temperature in the winter huts during October was 28° Fahr., the waters of the Gulf Stream between the island and the coast of Norway were in the same month 47° Fahr., that is, 19 degrees warmer; and during the month of January the atmospheric temperature sank to 22° Fahr., while the sea near Früholm remained at 37° Fahr., perhaps rose even higher in the open sea farther from the coast.

No other tract of land presents such peculiarities of temperature as this within the influence of the Gulf Stream, except, perhaps, East Greenland and Spitzbergen. Clavering's expedition, which anchored before Sabine's Island in the year 1823, gives us the following particulars. While General Sabine was at work in the observatory, Captain Clavering sent out a party with two small boats to row in fair weather along the coast. The passage took up twelve days, and every night the men slept in the tents they had taken with them, merely wrapped in their cloaks and rugs, without suffering in the least from cold. The temperatures in August were as follows: average temperature, 36° Fahr.; maximum, 52° Fahr.; and mimimum, 23° Fahr. On Bear's Island the average temperature at the same time was 34° Fahr.

Nothing is known of the course of the Gulf Stream beyond 75° N. lat. The heat of the water varies in summer between 35° 5′ Fahr. and 41° Fahr.; but on the west coast of Spitzbergen and beyond it, nearly as far 82° N. lat., the temperature of the water in summer is nearly 35° 5′ Fahr. At this point the heavy waters of the Gulf Stream sink below, and the lighter polar current prevails. The passage which the Gulf Stream seems to open up along the west coast of Spitzbergen toward the North Pole is, according to Petermann, nothing but a deceptive *cul de sac*.

One of the most important questions in reference to this subject is, what becomes of the Gulf Stream between Spitzbergen and Nova Zembla beyond 75° lat. Conclusive evidence has been received for some time past, which has not been sufficiently noticed and dwelt upon, that it does not come to an end there, that it sinks down and disappears beneath other currents. Before arriving at the regions of north-east and New Siberia, discovered and explored by many different travellers, we approach Taymir Land, the most northern point of Siberia. The report of Middendorff shows that the winter season in this place is relatively mild, far milder than it is farther south, and affords opportunities for fishing operations on a large scale.

A new light has been shed recently upon the characteristics of north-west Siberia, as to its climate in summer, and the amount of ice to be found there, by travellers who have recorded their experiences in the years 1866 and 1869. It is interesting to the student of polar geography to learn that no ice was found in the Bay of Yenissei (lat. 72° North), where it flows into the Arctic Sea. (July and August, 1866). The neighbouring tribes, who visit the bay towards the end of the summer season, assert that they never met with ice there, and the Russian settlers declare that, in the summer, ice is only brought to the bay by the west and north-west wind, and never by the north and north-east. It is also a remarkable fact, that those members of the expedition who penetrated to the open sea along the right shore of the Yenissei were never able to lay aside their winter clothing, while those busied on the western side had to suffer from intense heat and myriads of gnats.

In the summer of 1843, Middendorff had noticed at the highest point of Asia, that the sea lay stretched out before him perfectly free from ice, without his being able to discover the smallest piece floating upon its surface. Indeed, it may now be considered as an established fact, that to the north of Siberia, as far as we have yet penetrated, from 70° to 76° North lat., there lies an open Polar sea which is never frozen, and upon which, even in the coldest months, there is but little drift ice to be found. This fact, which has been demonstrated again and again within the last sixty years, by travellers of many different nationalities, is more than sufficient, because the sea whose freedom from ice it points out is situated north of the coldest regions of the earth. Some years ago there had been few voyages of discovery to the Arctic regions over the Polar seas themselves. Wrangell's expedition, which carried on its work of exploration for four years, is a distinguished exception, and the result of this expedition serves to show that at a time of year when the ice is hardest, and at a point lying north of the coldest countries of the globe, they came in a shallow sea upon ice which grew gradually thinner and more broken, and at last found themselves in an open sea, and this at a distance of only five versts, or three and a quarter miles, from the land. Eastward of the mouth of the Kolyma, Wrangell gives the average temperature of the Siberian frozen sea as 37° 30′ Fahr. during the month of July and 37° 10′ in August.

Another noticeable feature of the observations taken is the statement that in spring and summer the currents flow to the west, and in autumn and winter to the east, in the direction of the Gulf Stream. The proof that the latter course is the most prevalent is found in the fact that Wrangell, in his third journey, on the 26th of March, 1822 (72° 10′ north lat., 166° east long., Greenwich), found remaining on the drift ice the track of his sleighing course over which he had travelled in April, 1821, about twenty-three miles and a half farther to the westward, as he imagined, but in reality at least twice that distance; the current being east-south-east.

Although we are not inclined to recognize the influence of the Gulf Stream north of Taymir Land, we are ready to accept all Petermann's statements as to the effects of the current in raising the temperature of the west and north-west of Europe. As to the time required for the Gulf Stream to make its way through the whole extent of the Atlantic Ocean, great differences of opinion have existed and still exist among scientific men. Findlay, in the year 1869, considered that the waters of the Gulf Stream took two years to flow from Florida to Europe; but this view is contradicted by the following observation. When General Sabine was at Hammerfest in 1823, casks of palm oil were drifted ashore, belonging to a ship which in the previous year had foundered on the coast of Africa, near Cape Lopez, and therefore near the equator. Now if the distance from Cape Lopez to Hammerfest is compared with that between Florida and Europe, the time required would be nearer two months than two years.

We have now considered the Gulf Stream in its general aspects; let us attempt, before tracing it further, to look back upon its origin, to explore the forces which day and night, year after year, are employed in propelling this mass of waters from sixty to eighty times greater than that of all the rivers of the globe through the Straits of Bemini. The earliest idea concerning the origin of the Gulf Stream was that the Mississippi, or "father of waters," was also the parent of this current. The followers of this view did not explain how it was that while the Mississippi only carried down fresh water to the Gulf of Mexico, the Gulf Stream is one of the saltest of the ocean currents. The hypothesis is utterly untenable, and yet it has been again brought forward and made the most of in an amusing fashion by Catlin. This writer does not shrink from the fact, that even the great mass of the Mississippi waters are a mere nothing when compared to that of the Gulf Stream, but he says that below the Rocky

Mountains there flows a stream of far greater proportions than the Mississippi. This mysterious river receives in its subterraneous course the waters of Mexico, and falls through a number of mouths into the gulf of that name. According to Catlin, the Andes have also a river of the same kind, which flows into the Caribbean Sea. The Antilles, which are now partially submerged below the ocean, form a chain, which, according to Catlin, rose some 6,000 years ago above the surface as part of the chain of the Andes. At that time both currents emptied themselves in the ocean; and to their washing of the coasts, and the constant volcanic eruptions, the submersion of the Antilles must be ascribed. The tradition of this occurrence still survives, we are told, among the legendary stories of the Indians. At the same period the peninsula of Yucatan was submerged, but has since been again uplifted. All these statements are purely imaginary. Catlin forgets that his mysterious underground river must hold 3,000 times more water than the Mississippi, if it is to furnish the amount required at Florida.

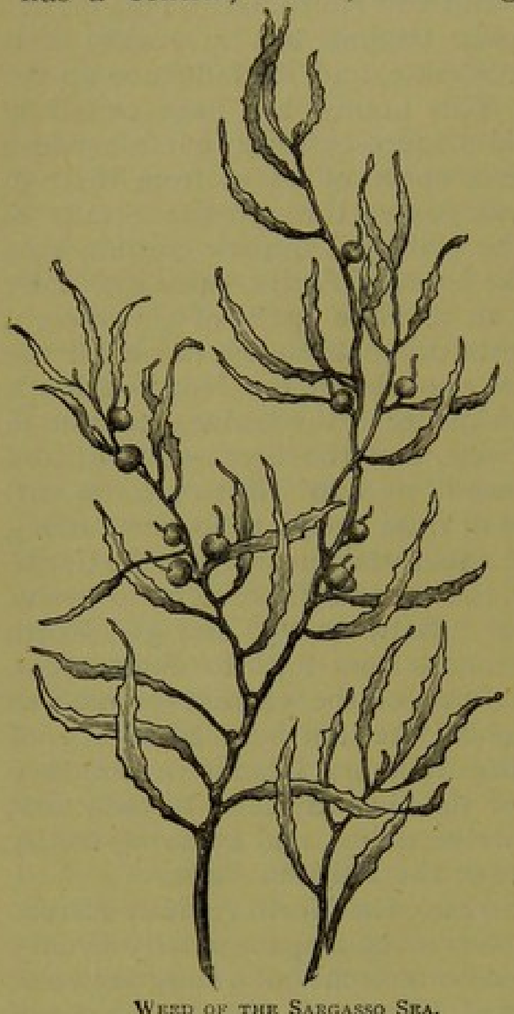
Franklin seems to be the first who threw a gleam of light upon the true causes of the mystery. He considers that the current is nothing else than the outflow of all the masses of water carried by the trade winds into the Caribbean Sea, and the pressure of these winds upon the waters is also the source of the motion of the Gulf Stream. Maury attempted to discredit this theory by showing that if it were true, the Gulf of Florida and the Caribbean Sea must have a higher level than the Atlantic, as a whole, since the waters must be, as it were, dammed up there. In the meantime there is no evidence to show that this difference of level does not actually exist. In reference to the Pacific Ocean, indeed, it has been established; for when the direct measurement of the latter was taken, it was found that the sea level in the Gulf of Mexico was rather higher than that of the Pacific. The pressure in the Gulf then is real, or rather the power of exerting the pressure which drives the warm current through the Straits of Florida. Franklin's theory is only defective, inasmuch as it looks upon the trade winds as being the only source of the Gulf Stream, while in reality these winds, as we have shown before, are but one among other causes of the equatorial current, which is the parent of the Gulf Stream.

This view respecting the origin of the Gulf Stream has recently received a valuable support and completion in Colding's researches. This writer bases his observations on the fact that the water on the east coast of Florida, near St. Augustine, is more than two yards below that of the Mexican Gulf. There must therefore be an outflowing current in that direction, although of course not a sufficiently large one to make up the whole current. For this another momentum, that of the earth's rotation, is necessary, and Colding proves this mathematically. This rotation works with accelerating force upon the Gulf Stream, just as if the current itself had a greater fall; moreover, it communicates to the surface of the stream a slight inclination toward the horizon. This last effect is the most interesting, and may be expressed in general terms as follows: all currents in the northern hemisphere, be their course what it may, must have upon the surface at least a tendency to rise from left to right. Now the force acting by means of the earth's rotation upon the Gulf Stream between St. Augustine and New York corresponds to a fall of about three and a quarter yards, and the rise of the surface from left to right amounts to nearly half a yard. In confirmation of this theory is the fact, which has been frequently pointed out, that the Gulf Stream never reaches the North American coast, but is parted from it by a stratum of cold water, like a "cold wall," as Carpenter expresses himself. This cold stratum, however, is not, as many writers were inclined to believe, a continuation of the cold Arctic current, but is made up of colder streams of water rising from the bottom of the sea.

Now that we have made ourselves acquainted with the sources of the Gulf Stream, we will go back to the description of its course, where we left it turning toward the south-east, between 40° and 50° North lat. This branch of the great current has not been so closely studied, but in reality it is of great extent, although its speed is but moderate, and its influence up the western coast of Europe relatively slight. This branch has been called by Scott the North African current. It flows in a south-easterly course between the Azores and the coast of Portugal, with a speed of about from three to twelve miles a day. An arm of this current passes through the Straits of Gibraltar into the Mediterranean Sea, but the principal branch continues its southward direction between Madeira and the coast of Africa, turns gradually to the south-west, and passes at last, with an average speed of six to eight miles, into the general westerly drift. By this designation we mean all the western currents which flow through the vast expanse of the North Atlantic Ocean between the North African current in the east, the Guinea current in the south, the West Indian Islands in the west, and the north-easterly and easterly margin of the Gulf Stream. Between 8° and 20° North lat. the current is more constant, with an average speed of from twelve to fourteen miles, and this portion of the drift presses with the equatorial current into the Caribbean Sea. Between 20° and 25° North long. the speed is from eight to twelve miles, and can be traced to 63° West long. Between 25° and 30° North the current becomes irregular, and only advances from four to eight miles. North of 30° North lat., the direction and force of the current become so weak, that this parallel may be considered as the northern boundary of the western drift. From 36° North to the Bahama Islands a contrary current may be noticed on the right side of the Gulf Stream, turning first to the south-west, and then to the south (twelve miles), and swerving finally to the south-east, where it follows the outline of the Bahama coast.

Within the space enclosed by the Gulf Stream, the North African current and the western drift, extends the Sargasso Sea over a space nearly twenty times as large as Great Britain, and covered with stretches of grassy seaweed. These floating meadows aroused the wonder of Columbus, and the terror of his crew, who thought that the ocean ended here in a marsh, from which it would be impossible to return. These masses of weed (*Fucus natans*) were once believed by some to have floated together to their present position, by others to be rooted at the bottom of the sea. Martius was the first to show that they floated free upon the surface; but it is doubtless very singular that the great mass should preserve its position in the open ocean. Humboldt estimated the extent of these fucus plains as reaching from between 19° and 34° North latitude and 17° and 27° West longitude. Within this immense expanse there are two principal fields, intersected by several small channels. More than twenty years ago it was suggested that the weed should be fished up and carried away to be used as manure. Whether this plan is practicable it is beside our purpose to consider; at any rate, no steps have been taken in the matter.

The members of the *Challenger* expedition have furnished the latest details as to this grassy sea. The floating masses of gulf weed (*Sargassum bacciferum*) are, generally speaking, from two to nine feet in diameter, but sometimes much larger. Occasionally, fields of several acres in extent are visible, and these larger stretches are generally found near the centre of the area of distribution. They consist of a stratum of feathery bunches of the *Sargassum bacciferum*, which are not entangled one with another, but float free at just a sufficient nearness to keep the mass together. Every tuft has a central, brown, branching, stem-like thread, covered with round air vessels, on short stems. Most of these air vessels in the centre of the plant have died out, and are covered with a pretty little white polyzoon. After awhile the bubbles so encrusted break away, and the sea is covered with these little isolated white balls. Not far from the centre of the plant, near the end of the branch, are the serrated willow-like leaves, brown and stiff at first, but nearer the end of the branch paler coloured, more delicate, and vivacious. The young fresh leaves and air vessels are generally adorned with the flowers of a campanularia. The prevailing colour of the whole is olive green of every shade; but the golden tint of the young growing leaves prevails. This colour, however, is often interrupted by the delicate branches flecked with the dazzling white of the encrusting polyzoon, and by the vivid blue of the sea gleaming through the open spaces of the network.



WEED OF THE SARGASSO SEA.

The effect of such fields and islets of algæ in sharp and yet harmonious contrast with the intense blue between them is very pleasing. These floating islands have inhabitants peculiar to them, and there is no more perfect example of the protecting power of imitation than that presented by the fauna of the gulf weed. Animals drifting to and fro upon the surface of the sea, with no other protection than such as is afforded by the single broken layer of the weed, must be exposed to countless dangers from the keen-eyed birds of prey above and the hungry fishes beneath them; but they each one imitate so wonderfully the form and colour of their floating home, and of each other, that we cannot be surprised if birds and fishes are deceived by them. Among the most wonderful of these creatures is the grotesque little fish, *Antennarius marmoratus,* seldom more than one inch and three-quarters long. It is this creature who rolls together his nest of weed by means of the fibres of a clammy secretion frequently found in the bed of the Gulf Stream. *Scillaca pelagica*, a shell-less mollusc, also inhabits this gulf weed, together with the little short-tailed crab, *Nautilograspus minutus*, which swarms all over the weed and every floating particle; and it is wonderful to see how closely the little creature corresponds in form and colour with the world it inhabits.

The Currents of the Mediterranean.

The Mediterranean is only connected with the open seas by the narrow passage of the Straits of Gibraltar, and affords some interesting studies in its system of currents. The great expanse of this sea, which extends over 864,000 square miles, receives but few contributions from rivers flowing into it, and at the same time suffers great loss from evaporation. There is good reason for believing that in the course of the year the evaporation over the whole surface very greatly exceeds the amount of water carried down by the tributary rivers, and this great mass of water has to be made good every year by the influx of currents from the Atlantic. There is found accordingly a strong outflow of the ocean waters into the bed of the Mediterranean, and it is this tendency which accounts for the North African current sending one of its branches through the Straits of Gibraltar.

By this influx of the ocean water the surface of the Mediterranean preserves its normal level; but as the masses of water which it throws off by evaporation leave their salt behind them, it seems to follow that this sea must be extremely rich in salt. Experience, however, does not show that this is the case. The Mediterranean is not much salter than the Atlantic, and the amount of salt within it has certainly not increased to any great extent in historic times. It is certain, therefore, that the salt must find its way out again into the Atlantic Ocean; and as there is but one passage open to it, there must be an outward current flowing through the Straits of Gibraltar.

There are, indeed, two currents in the Straits, an eastward current flowing into the Mediterranean, and an outward one into the Atlantic. The eastward current we know already; it is very perceptible in the centre of the narrow Straits, where it keeps its course in the face of the strong east wind, and reaches, where the Straits are narrowest, eight geographical miles an hour. Where then are we to look for the contrary current? Observations have been made which show us the westward currents along the European and African coasts, but these are only periodical streams which reverse their course at given times, flowing westward with the incoming tide, and eastward with the ebb.

These currents it is clear would be insufficient to effect the necessary compensation, and all these considerations point to the existence of a submarine current which carries off the heavy salt water along the bed of the Straits of Gibraltar to the ocean. It was received as evidence for this current's existence that the wreck of a ship which went down in the Straits, came ashore again on the coast of Morocco. But on closer examination this fact appeared no conclusive proof of the existence of the supposed submarine current. It is more likely that the side branch of the southward stream drifted the wreck to the African coast.

Carpenter was one of the first to furnish direct proof of this submarine current. The *Challenger* expedition estimated the power of the surface current at 218 yards. The water within this stratum had a specific weight of 1·0271—1·0276. Below this was a stratum whose specific weight was 1·0290, which increased at the bottom of the sea to 1·0292. This last stratum represents the heavy salt water of the Mediterranean flowing westward, and the upper contains the inflowing water from the Atlantic. We see then here the equalization of the outflowing and inflowing waters, and mark how the salt which reaches the Mediterranean by the eastward current is sent out again to the ocean whence it came.

In the Black Sea the amount of water received from tributaries is in excess of the loss by evaporation, and the overplus of water flows through the Straits of Constantinople, with a speed of from two to four geographical miles, into the Sea of Marmora. This current, however, is accompanied by side streams branching from it, and has also a contrary current below it.

A curious phenomenon is observable with respect to a purely local and weak current in the Mediterranean, the cause of which is a mystery to this day. The current spoken of is continually carrying off sea water into rifts and openings of the rocks, without its having been found out where the water so carried remains. The phenomenon is witnessed on the coast of the island of Cephalonia. The west coast of this island lies so deeply embraced by an arm of the sea flowing from south to north, that a great tract of land is almost cut away by it from the island. This deep bay cleft in a south-easterly direction by a chain of rocks lying from south to north, opens where Argostoli lies within the inner side of these rocks into a wide and safe harbour. It had been observed for a long time that the rocky coast, which a little to the north of the town was split into numerous clefts and openings, received within it, by an uninterrupted current, a continual supply of sea water. The practical result of this observation was that a channel of about eleven to sixteen and a half feet long was cut in the rock at a little distance from one of these openings, and at its entrance the water power was used to turn the wheels of a flour mill. There is then actually a real sea-water mill, or rather there are now two such mills.

The locality has been closely examined to find some explanation of this unique phenomenon, and several hypotheses have been put forward for the purpose. The supposition of an absorption of the water into porous strata of earth, to be afterwards carried to the surface, and there sent out by evaporation, was at once rejected, as soon as the island, and especially the geological formation of the spot where the mill is erected, had been examined.

The whole island, we learn, consists, as to the rocky base on which it stands, of limestone, on which, here and there, in small stretches, are found upper strata of the more recent tertiary formation. The very place where Argostoli and the mills are built, as well as the whole reef which shuts off the bay of Argostoli from the western sea, is formed of a very coarse limestone hollowed into cavities, and filled with little rifts and fissures, but by no means of a porous character—indeed, presenting here and there the appearance of an oyster bed. The ground is the same as that on the other side of the bay at Luxuri. Near to this calcareous earth is a widespread stratum of fossiliferous marl, which is certainly capable of receiving water, but then this quartiary marl is situated above the limestone, and is never found in contact with the sea. The only stratum then which is capable of receiving the waters of these currents is put out of the question by its position, from affording any explanation of the puzzle.

Another hypothesis suggests that the water sinks down into the earth to such a depth that it is changed into vapour, which, in these centres of volcanic action, would easily find ways of returning to the surface. Against the acceptance of this supposition as an explanation of the currents at Argostoli, it is answered that the volcanic centre must be close at hand to the stream of water absorbed; and that on the whole island of Cephalonia, and even on the neighbouring island of Ithaca, no trace of such rocks are to be found, although it cannot certainly be denied that the region of earthquakes, which appears to have Zante for its central point, extends to the spot of which we are speaking.

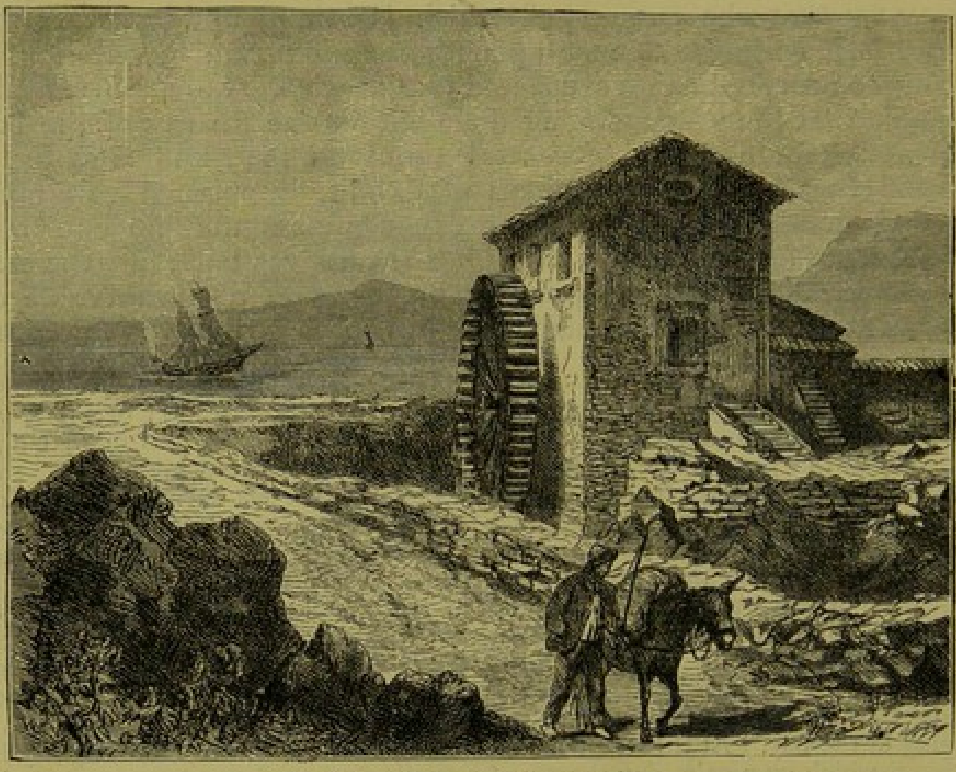
A third hypothesis seeks to ascribe the phenomenon to an unequal distribution of the upper strata of sea water, and is inclined to suppose a subterranean flow of the currents toward the sea on the opposite side of the island. It would be enough for any causes to excite a pressure against the western side of the island, and an outflow on the eastern to account for the movement perceived. But if this be obtained, it is natural to ask for the outflowing current on the other side of the island. No trace of such currents is to be seen there, and even if the difference of level could be explained by the influence of a strong west wind, the changeableness of the cause can hardly be brought into correspondence with the constancy and strength of the current, not to speak of the improbability of such streams being able to flow through three mountain chains, and the hindrances to be overcome on their way by the extent and irregularities of the rocks against the force of a feeble current.

It may be that the west wind, which is strong and constant at this locality, exerts a certain influence upon the phenomenon in question, but it can scarcely be accepted as its cause and explanation. Mousson considers it most probable that the water sinking deep within the fissures of the land is warmed through at a depth of several thousand feet, and rises by other channels, and thus produces, by means of definite superficial variations, an uninterrupted circulation of the water. He confesses that no one has discovered the places at which the waters pour themselves back into the sea, but he adds that these places may possibly be found at a considerable depth below the surface. A later explanation has been given by the botanist Unger :—

"In my botanical excursions to Argostoli," he says, "the condition of the bay often formed the subject of my investigations. It did not escape my notice how many tributaries flow into the sea at this place, from streams which simply and collectively have the same or a very slightly higher level than the surface of the sea. Of the six springs which are found on the inner coast of the bay, each one seemed to me to have sufficient force to turn a mill like the one at Argostoli. The majority of these springs contain good drinking water, but some that break forth from the limestone on the north are rendered undrinkable by the strong admixture of salt water. It was not until the place came into the hands of the English, that the town was brought into connection with the opposite shore, by means of a low-arched bridge about a mile long, which renders the communication extremely easy. I was much astonished on noticing that through the arches of this bridge, and especially through those farthest from the town, there was a strong current flowing north-west, that is, to the opening of the bay. At that moment the strong north-west wind was slightly impeding the current, which on a calm day shortly afterwards appeared much stronger and more clearly marked. This seems to me to place beyond a doubt the fact that there are constant variations of the level of the sea, differing in degree according to circumstances, taking place between the inner and outer parts of the bay. These circumstances gain in significance when we compare them with similar phenomena on the eastern side of the island. Here, too, by the Gulf of Samos are several mills like those of Argostoli, close by the sea shore, but what is remarkable about them is, that unlike those of Argostoli, they are not turned by the sea, but by springs which break forth from the limestone scarcely one and a half foot above the level of the sea, and lastly, that these springs contain salt water.

"But although the phenomenon of Argostoli stands alone, that of Samos is frequently noticed ; as far as concerns the breaking forth of partly fresh, partly brackish springs in places lying on the sea level. I recall the salt lakes near the ancient Eleusis ; and there are here numerous saltish springs lying in a marshy lowland cut off from the sea by a raised dam. In two places the dam was broken through to admit the outflow of the waters within the marsh, and the current produced was so strong that it was sought to render it available for a mill, but from neglect or other causes it is not now in working order. Upon the little tongue of land where Eleusis lay of old, numerous springs, scarcely higher than the level of the sea, are found on the west coast, which are only very little higher than the sea level, and which betray their situation from afar off by the more luxuriant vegetation, and especially the rich growth of marshy plants. The least salt among them were used for washing linen. Several other low-lying lands of Greece, especially the plains of Argos, Messene, and North and South Peloponnesus, seem to be distinguished for this kind of spring; and the early system of cultivation must have been determined by their presence, as, without using them for purposes of irrigation, etc., no wheat-growing districts would have been possible upon such a soil. These observations, and many similar ones, which could easily be adduced, establish beyond all doubt the fact that in the otherwise scantily watered plains of Greece there are abundance of these springs, which break out only a little above the level of the sea, and whose water has a greater or less admixture of sea salt.

"If, then, in reference to the special case that we are considering, it is scarcely probable that the meteoric water in its passage below the surface of the earth becomes impregnated with salt particles, but rather that the salt which is found in it owes its origin to the admixture of sea water, the whole question resolves itself into this, how is this water raised to the height of two or more feet, conducted into greater or smaller reservoirs, and there brought in unequal proportions in connection with fresh water? A rising of the sea waters in more or less enclosed channels, where they gather together and discharge themselves in a constant flow through an opening below the surface, is a supposition which presents itself without



Sea-water Mill at Argostoli.

difficulty upon a careful examination of the locality, and of the outward agencies brought to bear upon the moveable surface of the sea.

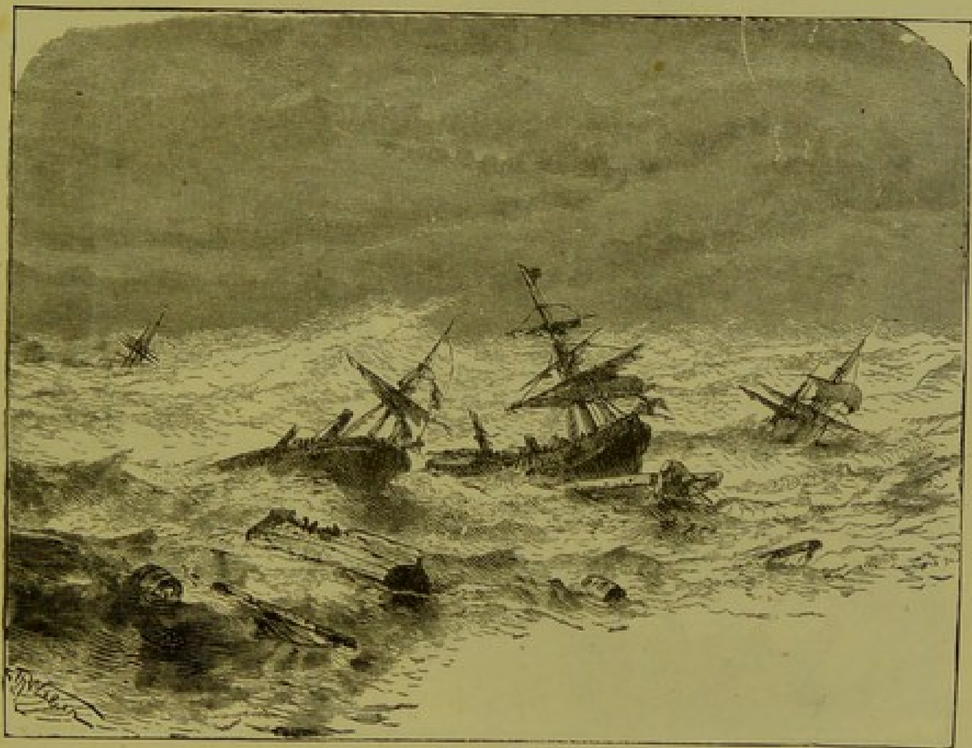
"It cannot be denied that the construction of the bay of Argostoli is precisely such as to cause a considerable uplifting of the waters during the prevalent west or south-west winds, and so to occasion an alteration and rise in the sea level. Could not this water so raised, aided by the force of capillary attraction, be sent through the numerous small fissures which abound everywhere along the coast, and carried into some great subterranean basin? If now this salt water thus raised came in contact with the fresh rain water which penetrates the earth from above, and the mixed streams were finally to reach the sea level again through various small openings, we should have all we need to explain the phenomenon of Argostoli.

"The case of the sea-water mills at Argostoli would then present exactly the same case as the apparently opposite case of the mills of Samos. Here the spring is collected into a basin before it flows out into the sea; there the basin is wanting, or rather, it is of greater extent; for the whole extent of the gulf may be looked upon as such. Moreover it has long been known that fresh water as well as sea water flows into the channels used for the mill at Argostoli, and in such quantities that the water of the sea into which the mill streams flow, loses much of its salt taste. This fact, however, also shows that it is probable that large quantities of fresh water flow into the sea at this place through subterranean passages."

FOREST SCENE IN FARTHER INDIA.

Currents in the Baltic.

The Baltic receives, from its many tributaries, more water than it can dispose of by means of evaporation, and the result is that we find a surface current flowing away to the east through the Sound and the Belt, while the salter water flows in beneath it from the North Sea. The salt of the North Sea amounts to about $3\frac{1}{2}$ per cent.; the waters of the Skager Rack contain only 3 per cent., or even less; the Kattegat, 2 per cent.; the Great Belt, 1·27; and the Sound, near Helsinfors, only 0·925; but in the depths of the Skager Rack the amount rises to 3·6 per cent.; and in the Great Belt there has been found, with a south-east current, where the water is seventy-two yards deep, an amount of 1 per cent. on the surface, which increased only in a slight degree to the depth of $23\frac{3}{4}$ yards; but at a little more than a yard below, where the submarine current from the north made itself felt, reached 3 per cent.

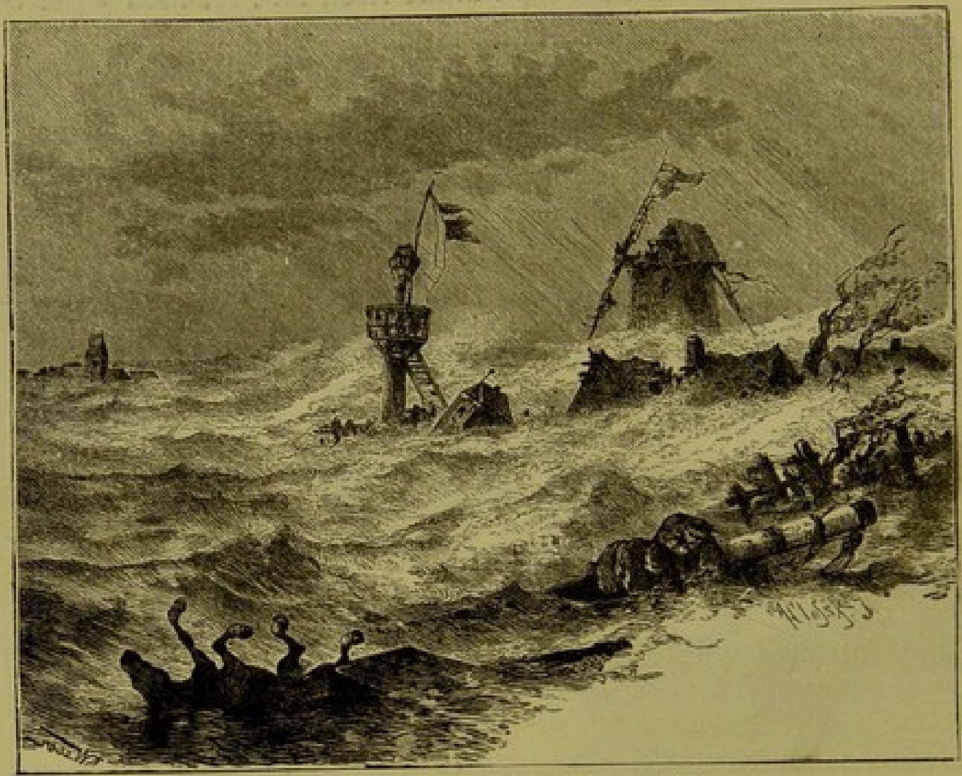


Shipwreck on the Baltic.

The following conclusions have been established by the study of the distribution of salt in the Baltic. First, that the heavier, and therefore salter water is found in the lower strata of the sea; but that the difference between the surface and deep water is less marked in the east basins, where there is less salt, than in the western. Secondly, that this difference scarcely varies at all in the eastern beds, while in the western there is throughout the year a marked variation, the waters of the Baltic being salter in autumn and winter than they are in spring and summer; and besides this annual difference, the amount of salt is found to vary from year to year. Thirdly, that on the one side the longer or shorter duration of the wind from that quarter, and on the other the greater or less precipitation, exerts an essential influence upon the force and extent of the salter current, and can cause it to press farther eastward through the sea's depths, or to retreat westward.

The chief current of the Baltic rises in the Gulf of Bothnia, and sets out undivided as far as Aland Islands. Here it divides into three branches, of which the most westerly continues southward between Gothland and Oeland. The other two are broken up by the numerous islands upon the coast of Finland, but unite at length with a strong ocean current flowing into the Gulf of Finland, and, advancing to the south-west, meet again with the other branch at the south of Gothland. The combined branches now flow round the Island of Bornholm, and continue their way toward the western half of the Baltic Sea, where they flow out into the ocean through the Sound and the Belt.

At times, however, the strong north-west winds bar their exit, and force back even the surface waters of the North Sea into the Baltic. The influence of the wind is stronger in the Baltic than in any other sea of the same extent, so far as concerns the currents and the height of the water. The surface of the sea rises eastward from Kiel, gradually, but so that at Pilau it is about three-



FLOOD ON THE COAST OF SCHLESWIG.

eighths of a yard higher. This rise is occasioned chiefly by the prevalence of the west winds; for during the contrary winds the rise is less, as has been often shown by the monthly high-water tables. The effect of the wind on the surface level of the Baltic has been carefully noted, especially with reference to the disastrous floods of November 13th, 1872, and we learn the following details :—

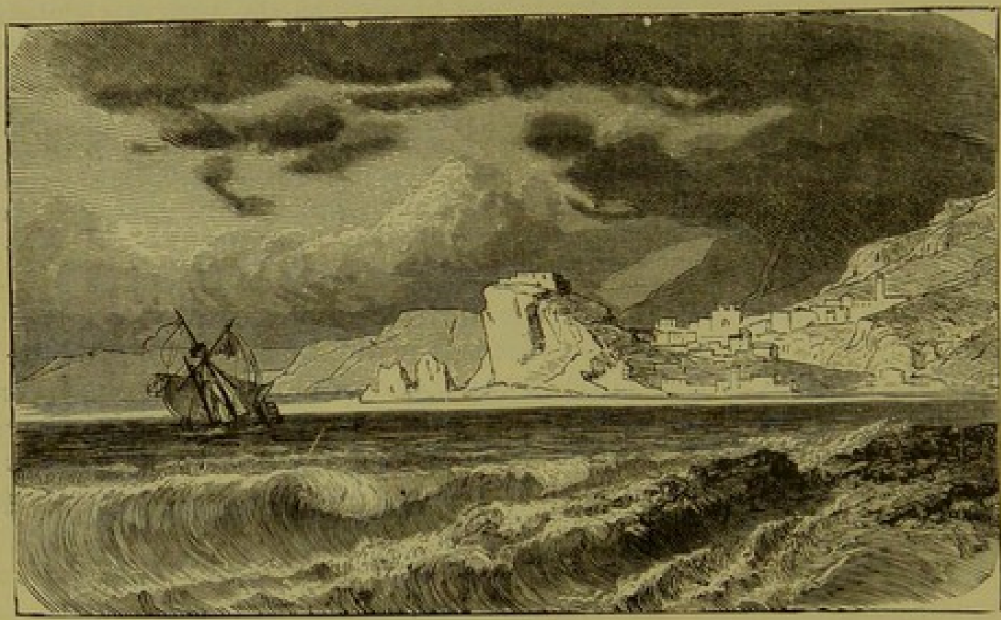
"The north-east winds which prevail in spring drive the waters westward, where they flow out through the Sound and the Belt, into the Kattegat, and this discharge is rendered easier by the low level of the sea at this time of the year. The outflow of the waters into the North Sea is strengthened by the same winds on one side in the direction taken by the current of the Baltic itself along the coast, and on the other by the current through the Sound. Along the coast of Pomerania, which, from its long straight outline, offers great facilities for such observations, the coast current flows westward when the wind blows from north-north-east to the east and south-east; and eastward when the wind blows form south-west to the west and north-west. When any other wind prevails, the direction of the current is slight and changeable. When the wind is blowing from the north-east by the east and south, to the south-west the current flows into the North Sea; and into the Baltic Sea when the wind comes from the west and blows by north-west to north. Risings of the sea's surface of one and a half to two and one-eighth yards are frequent in stormy weather; but since they occur in many places, they are neither particularly dangerous nor noticeable. Flood tides of greater height than this are rare, and, according to records taken for some considerable period of time at Lubeck, and which may be considered as forming a standard for the other parts of the sea, only six floods have reached higher than two yards over the regular high-water mark since the year 1625. Three of these floods rose more than two and three-quarter yards, and only one more than three and a quarter yards. This last was the flood of November 13th, 1872, and reached the unprecedented height of three and a half yards. From our human point of view, everything that could heighten the calamity—direction, continuance, extent, and wind—were combined to one end. On the 18th of November, 1872, the wind was slack, the water nowhere above or below its average height, and the ominous direction of the wind, north-east and east-north-east, were only recorded at Swinemunde and Rugen. On the 11th of November the tragedy began by the north-east and east winds blowing upon every station on the coast except Pilau, and the western parts of the sea rising half a yard; the current in the Sound near Copenhagen is now reversed, and carries back for several days the waters of the Baltic into the North Sea. On the 12th of November the wind gains in strength, and is recorded as "stormy," and its course is east-north-east on Rugen and east of Rugen, but north-east to the west of Rugen. The storm wind drives the waves straight away from the Russian coast to Travemunde, four hundred miles distant, and by nightfall the water has already risen two and one-eighth yards at the entrance of the little town; and almost as much along the coast of Schleswig Holstein. On the 15th of November, the storm, still in the same quarter, increases in violence, and rises to a hurricane along the stretch of land between Kiel and Rugen, reaching its greatest strength, as far as can be learnt from the observations, at about eight in the morning at Rugen, at ten o'clock at Kiel, and noon at Cuxhaven; the water at this time was more than three and a quarter yards above high-water mark. The catastrophe was now accomplished, and the tragedy neared its end. As soon as the wind began to abate it veered to the east and south-east, and on the following day it was gone down at every station, and the sea level had almost regained its normal height."

Such are the broad outlines of the terrible floods of 1872, and in their simplicity they correspond with the vastness of the phenomenon. If we look upon the whole extent of the Baltic to the south of Gothland as one basin, the wind which traversed it from east to west in its widest expanse carried the eastern waters to the west coast, and, owing to the funnel-shaped construction of the bed of the sea, the rising on the west side was much more perceptible than the depression on the east coast.

Whirlpools.

In close connection with the ocean currents are its whirlpools, which were formerly regarded with so much terror by the seafarer. These whirlpools are rotatory movements of the water round a funnel-shaped central point far below the surface, towards which the waves are drawn in spiral windings, and where they seem to disappear. Erroneous ideas as to the method of this watery movement had led to the supposition that the whirlpools were caused by the fathomless depths of water below them. This idea is utterly false, for the whirlpools are not caused by any sudden descent of the sea's bottom, but through the meeting of contrary currents, and their danger to the sailor has been much exaggerated both in classical and mediæval times. The most famous whirlpools are those which, under the names of Scylla and Charybdis, rendered the Straits of Messina a terror to mariners in old times. From the heights upon the coast we can get a good view across the narrow straits, and look complacently down upon the "howling monster," as it shows itself here and there in dark spiral rings, round which the waves are concentrated. If it were not established as an historical fact that half the fleet of Octavianus was wrecked in this place, it would be almost impossible to believe that such an insignificant little whirlpool could present any danger to the sailor. At the present time the harbour of Messina is always alive with ships, which take but little notice of the whirlpool, a convincing proof of the great advance in modern civilization. In summer the larger sailing vessels occasionally sail right through the centre of Charybdis, and fishing boats carry on their harpooning close to the dreaded rocks of Scylla.

Scylla is a high rock on the coast of Calabria, which rises vertically out of the sea, and at its base is excavated into a number of deep hollows. The tidal currents and the two principal currents of the Mediterranean strike directly against this rock with great violence, and the foaming waves rushing into the deep caverns, and filling their vaulted arches with surging floods, give forth a sound not very unlike the barking of dogs, recorded in the fables of antiquity. In fair weather the waves flowing into the narrow straits from the south, and aided by the wind blowing in the same direction, carry the ships at great speed, but, thanks to the care and skill of their crews, with perfect safety, past the once formidable Scylla. The same thing occurs with the ebb tide



SCYLLA AND CHARYBDIS.

flowing from the north, and its accompanying wind. If these winds are at all violent, the current is so strong that no anchor can stand firm, and the lead is driven upward to the surface; but if wind and current are flowing in opposite directions, the contrary current seizes the ship which entered the Faro with a favourable wind behind her, and dashes her back against Scylla or the adjoining sandbank. The same catastrophe is sometimes brought about by the conflict of two opposite currents, one flowing down along the coast of Calabria, and the other along the north coast of Sicily. The encounter sets the waters in violent agitation, which is made more dangerous by the presence of a sunken reef in the midst of the channel. This current, however, does not extend over the whole expanse of the Faro, and the practised Sicilian pilots know its every turn and bend so thoroughly, that if they are summoned in time they can guide any ship through its waters, while without their aid the most experienced sailor would be lost.

Charybdis lies on the Sicilian side of the straits, about nine geographical miles from Scylla, between a narrow tongue of land called Punta Sacra, which forms the harbour of Messina, and another called Calofaro, in which a lighthouse has been erected. Part of the current flowing through the Faro strikes against the rock of Calofaro, and, meeting there several side currents, forms with them the whirlpool of Charybdis. Its central point is a surface of circular form, measuring forty feet in diameter, within the circumference of which a constant rise and fall of the water takes place. The waves beat against the rock, and are cast violently back. Below this circle the straits are only 520 feet in depth, while beyond it they are nearly twice that depth. The centre circle never presents the appearance of a whirlpool, even in the stormiest weather ; and far from drawing the passing ships towards it, its influence is outward and repellant, and is felt as such by vessels at a considerable distance. When the wind sets in strongly from the south, and there is a swift current running, several little whirlpools are formed on the surface, and the dashing waves overturn any small craft within their reach, or sink them by filling them with water. If a large vessel enters the circle, the wind immediately seizes the sails and rigging, so as to make manœuvre impossible. Sometimes the current and south wind combined will carry the ship safely through, past Charybdis, to the north end of the straits, and then dash it to pieces against Scylla's frowning rocks.

On the whole, however, the Straits of Messina have lost much of their former evil character, partly because the inequalities of the sea's bed and the effect of the currents have changed, but partly also because the art of navigation is so much better understood. But even yet the rock and the whirlpool are dangers to be shunned. The fresh wind which generally rushes through the narrow straits often spurs on the current to resistless speed ; the mountain peaks of Calabria and Sicily sometimes catch the wind, and sometimes throw it back with violence, and thus produce upon the waters an alternation of windless calms and heavy squalls. If a ship happens to be near either danger at such a moment, she is easily drawn in, and the smaller vessels are sucked down, while the larger ones are dashed against the rocks.

One of the whirlpools most dreaded in the middle ages is the Maelstrom, between the islands of Moskoe and Moskenas. For many centuries this whirlpool was the terror of navigators, and report exaggerated its dangers and extent to the most monstrous proportions. It was said that its diameter, measured from its outermost circle, was three to four miles across ; and that every ship which was caught within this outer circle was irretrievably lost, by being drawn with dizzy and ever-increasing swiftness toward the inner narrower circles, until it reached the centre, and was sucked down into the fathomless whirling depths below. The most gigantic whales were reported to have been seen vainly putting forth their mighty strength against the circling eddies, and trying to escape from the fatal spot.

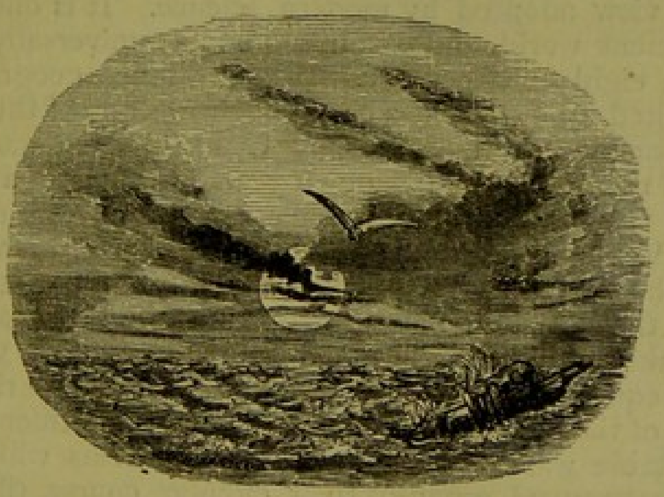
But the more faithful reports of modern times have greatly diminished the fantastic terrors with which the lively fancy of the middle ages delighted to surround the Maelstrom. This whirlpool is created by the conflict of the tidal currents, which in its turn is occasioned by the configuration of the neighbouring coasts. The Lofoden islands, which are separated from each other only by very narrow channels, form with the mainland a basin called Westfiord. The tide, flowing up northward, brings with it a vast mass of water through the Lofoden, and drives it on toward the east, and because the narrow channels between the islands do not allow room for it to flow through, it is heaped together within the bay. A strong current sets out from these swollen waters back to the south, just where the bay is shallowest, namely, at a cliff standing in the channel between Varoe and Moskenas. Here the backward flowing current is met by the tide running swiftly northward, and within the narrow space of a few miles there is created a circular movement from south through south-west, west, north-west, to the north. At the time of ebb tide, when the volume of water stored up at the north side of the Lofotes flows through them, and breaks against the Moskoe cliff, and there falls in with the ebb tide, retreating southward, the corresponding movement north, through north-west, west, and finally south-west, is created. These double rotatory movements form eddies which are very dangerous in the spring tides. In fair weather, and with the ordinary tides, the Norwegian fishermen choose this spot for their principal fishing station, because of the abundance of fish found within its waters, and they allow themselves to be carried round and round by the eddies, without vouchsafing them any attention; while the larger vessels can sail quietly through the midst of the whirlpool, since the largest eddy is only eleven feet deep.

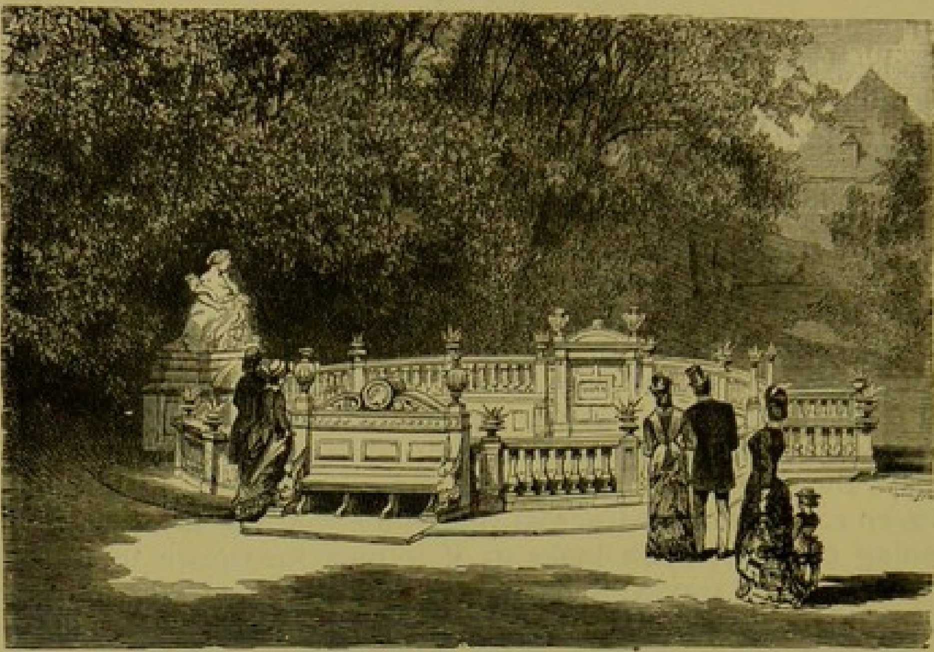
Eddies of considerable size and importance are formed by the tides on the west coast of Scotland. Between the islands of Jura and Skarba is the famous cave of Coirebhrecain, which, according to those versed in the Gaelic tongue, signifies Caldron of the Seas. Through the channel, three-quarters of a mile wide, which is enclosed between the savage precipitous coasts of the two islands, the sea runs at a speed of nine miles and a half an hour, and the flow and ebb tides meet. At the rate of velocity we have mentioned it is inevitable that their encounter should produce eddies and whirlpools, but the violence is relatively insignificant. Where, however, the channel approaches its western mouth, not far from the coast of Skarba, a cliff or shallow is met with, which raises the bed of the sea to such a degree that the water is here only a fourth part as deep as in the other parts of the channel. In this place the sea rages with terrible fury. If the current is running to meet the wind, and especially if it is the outflowing current running to face the west wind, the whole channel is covered with great heavy waves. The roar of the surge can be heard at an immense distance, and to the westward in the open seas the current is recognized miles away by the white crest of its foam-tipped waves.

From this description it is evident that no whirlpool in the true sense of the word exists at Coirebhrecain. There are circling eddies, it is true, like those which rise upon the surface of a swollen river, and it would be a very difficult undertaking to steer a boat in a true course through the channel; but when the wind is mild and the sea at rest outside the passage, even a small boat can pass through the dangerous spot in safety. It is said that in the year 1864 a ship was drawn out of her course by the current, and abandoned by her crew, and that after a week had gone by she was found unhurt on the shores of a little bay on the east side of Jura. With a calm sea, the channel is as quiet as any other place near, and the stranger who visits the famous spot will find his illusions of storm and danger dispelled.

Advancing along the wild coast of Skarba, we arrive, between that island and Lunga, at a place marked upon the Admiralty's charts as Wind-dog Pass, a designation which we confess ourselves unable to analyse more closely. This opening is known to sailors as the little gulf. The water here is not so deep as in the great gulf, but the spectacle is much grander and more interesting than that of Coirebhrecain. When the traveller finds himself upon the eastward or inner side of the islands, he can watch from his vantage ground close at hand how the sea rushes through the passage, and he will then have an opportunity of looking on such a current as he has probably never seen before. It is carried along at galloping speed by the foaming seas, while, three hundred feet away, the spectator becomes aware of another similar current rushing to meet it. Whoever is bold enough to plunge into this current finds himself shot back like an arrow from a bow to the place whence he came.

Between and close round these two currents the sea boils and surges in indescribable fury. About thirty feet away a foaming whirlpool is created. Across a diameter of about forty or fifty feet it appears to move like a gigantic corkscrew towards the bottom of the sea. The boatmen on the island say that they have been caught by the eddies, and driven round and round with great speed, but they do not seem to attach any special idea of danger to the experience. When the current is running outwards, it is advisable to approach the spot with caution; but the enjoyment of the spectacle repays the risk attendant on the enterprise. A long line of surging waves is seen rolling outward across the whole width of the channel, to meet the incoming current, which looks as if it must be drawn under the white foaming crest of the waves; but it rises to meet them with an amount of uproar and defiance which may easily try nerves unused to such sights. The current reaches its greatest height at the time of new and full moon, at mid-day and midnight, when it is outward bound, and the incoming stream is highest at six o'clock in the morning and evening. On each succeeding day the maximum of strength is reached fifty minutes later than on the preceding.





THE SPRINGS OF THE DANUBE.

CHAPTER IV.

THE WATERS OF THE MAINLAND.

THE volume of water flowing through the mainland is very inconsiderable when compared with that of the ocean from which it comes; for our rivers are, generally speaking, nothing but water withdrawn from the sea by evaporation, and afterwards returning to their source.

Such is the view adopted by modern science. It is one which was unknown to the ancient world, and was by no means universally received at the beginning of the eighteenth century. In the famous geography written by Varenius, and edited by Newton—a book which was one of the text-books used in the lecture rooms of the University of Cambridge—it was stated that the greatest rivers of the globe carried down yearly to the sea a volume of water which exceeded the volume of the globe itself. This was said especially in reference to the Volga, and the conclusion drawn from the astounding statement was that the river water so carried down was incessantly flowing back to the land from the sea. We have already stated that in reality all the rivers of the world would have to flow incessantly for fifty million years to furnish a mass of water of equal volume with that of the globe. The rivers, which carry life to every part of the world, and without which the continents would become barren, uninhabitable wastes, are like a network of veins which carry back to the ocean, or great central organ of their circular course, the water which is shed upon the earth by the arterial system of the clouds.

Were it not for the immense quantity of water within the ocean, no moisture would be possible throughout the world, no rain would water the parched fields, no spring break rippling from the rocky cavern, no river roll its broad waves between its fertile banks. The invisible vaporous cloud which rises from the ocean into the air is condensed into the form of mist and cloud, which fall down as rain or snow upon the earth, and feed the rivers. The rivers, flowing downward to the sea, lose part of their waters by evaporation, part is chemically absorbed and retained in the locality, and the great bulk is carried on to the ocean, to repeat the journey just described. Such is the famous circular course of the waters, thanks to which the mainland is inhabitable, and organic life preserved upon the earth's surface.

SPRINGS.

Springs hold beyond all dispute a high rank among the most curious and interesting phenomena which arrest our attention in a study of the globe on which we live. In every age the place at which living waters welled out of the bosom of the earth has exerted a power of fascination upon the mind and fancy of the human race, whether in the rich, flower-filled valleys, or in the wild scenery of mountain solitudes. A strange mysterious charm haunts the spot where the clear crystal of the spring starts to light from the hidden recesses of the earth, and the traveller feels as if he had fallen under the spell of unknown but friendly powers. That this experience is no special property of our modern subjective age, is shown by the stories of the old world, when every spring had its kindly guardian nymph, when echo haunted the rocky grottoes of its source, and friendly genii watched over the sacred waters. The triumph of Christianity drove the fabled gods of heathendom from their resting places, but did not destroy the deep pathetic charm which lingers still within the human heart, and finds expression in the songs of many of our modern poets, some of whose finest thoughts have been called forth by the sight of earth's fresh springs.

In every part of the world these springs have surprised the careful explorer, at the base and on the crest of mountains, in wide lowland plains, on sea shores, in marshy swamps, in the beds of rivers, and at the bottom of the seas. We have already spoken of the submarine springs in the Antilles, south of the island of Cuba. Many springs are known to exist at the bottom of the sea off the department of Bouches-du-Rhone, at different distances from the coast. One of these springs, that of Port-Miou, near Cassis, forms a noticeable current on the surface of the sea, capable of floating down to a great distance any object thrown into it. At Saint Nazaires, Ciotat, Cannes, San Remo, and Spezzia, fresh-water springs have been found welling up within the sea, and an attempt has been made to estimate the amount of water they carry down. The French geologist, Villeneuve-Flayos, rates the amount flowing through the submarine tributaries of the Mediterranean between Nice and Genoa at twenty-four cubic yards a second. Many submarine springs along the Provençal and Ligurian coasts arise at great depths. The spring at Cannes rises 180 yards below the surface, that of San Remo at 318 yards; and 6,558 yards south of Cape St. Martin, between Monaco and Mentone, a fresh-water stream is said to rise at a depth of nearly 765 yards.

In the *mare piccolo*, or harbour of Taranto, not far from the mouth of the Galesus, there is such an outbreak of fresh water, that it can be drawn out of the sea without any brackish taste remaining in it; and in the salt lagoons near Cette, in a deep part of the Avysse, a stream of fresh water breaks forth with sufficient force to produce waves. At Ragusa, the Calmotta channel in the harbour of Val d'Ombla is fed with fresh water, which pours forth from the Ariona, a subterranean stream, with wonderful power and volume; and fresh-water streams are found also in the harbours of Cattaro and Aulona. In Agio Janni, below Parga, between the mouths of Acheron and Thymamais, is a circle of about forty feet in diameter in the middle of the sea, through which the fresh water rises in great force. This spring is probably the one spoken of by Pausanias. Before the little island of Ruad by Tortosa, on the Syrian coast, a stream of fresh water flows into the sea with such power that it can be drawn out free from any admixture of salt.

Aristotle approached the truth with regard to the origin of springs near enough to ascribe them to the meteoric water which had filtered through the ground. Descartes thought that the water from the sea penetrated by means of subterranean channels to the very heart of the mountains. Here they were transformed by the heat of the earth into vapour, driven upward to the surface, and appeared there in the form of springs. These rather complicated suppositions were rendered necessary by the fact that the heaviest summer rain never penetrates the earth to a depth of more than seven inches or thereabout. Lahire refused his assent to the meteoric origin of springs, because he found that a flat piece of lead which he had placed below a stratum of earth eight feet deep, and had left for fifteen years, had never received one drop of water from the summer and winter storms which had burst over the earth above it. Buffon also found, in turning over in his garden a mound of earth ten feet high, that the rains of many years had never penetrated below four feet from the summit. These and similar important experiments could not fail to attract attention, and the celebrated physicist, Mariotte, determined to institute a close examination of the subject. He chose for his purpose the river district of the Seine, comparing the amount of rain which fell upon its area to the mass of its waters. He found by his experiments that the Seine carried to the ocean only the seventh part of the water it received in the form of snow and rain.

These investigations as to the amount of the rainfall have been renewed with more accurate measurements. Arago disputed some of the results. He says that the basin of the Seine has a surface extent of 10,817,500 acres as far as Paris. If the surface of the earth were horizontal, and if the rain water did not evaporate or fall into the ground, it would form in one year a fluid stratum of twenty inches in height. It is easy to reckon that such a stratum would contain 29,813 million cubic yards of water. The average amount of water flowing into the Seine amounts to 331 cubic yards a second, or 10,454 million cubic yards of water in a year. The proportion of this last amount to the yearly amount of the rainfall of the district, (29,813 million cubic yards) is as 100 to 285, or nearly as 1 : 3. The amount of water which flows yearly under the bridges of Paris is only the third part of that which falls as rain upon the district. Two-thirds of this rain water either returns into the atmosphere by evaporation, or becomes the food of plants or animals, or pours itself by means of subterranean channels into the sea. If the water which had flowed down every river through its subterranean outlet were distributed over its surface, it would form at the end of a year a fluid stratum six inches high for the Garonne, four for the Saone, sixteen and a half for the Rhone, and these figures are less in the proportion of two to nine than those contributed by the rainfall.

Dalton has attempted to give the proportion between the rainfall and the discharge of waters from the rivers of England. He finds that the rainfall gives a yearly average of nearly three-tenths cubic miles of water, while the amount carried into the sea is only one-tenth cubic mile. This leaves then a remainder of about two-thirds of the rain water to be thrown off in evaporation, or become the support of organic life.

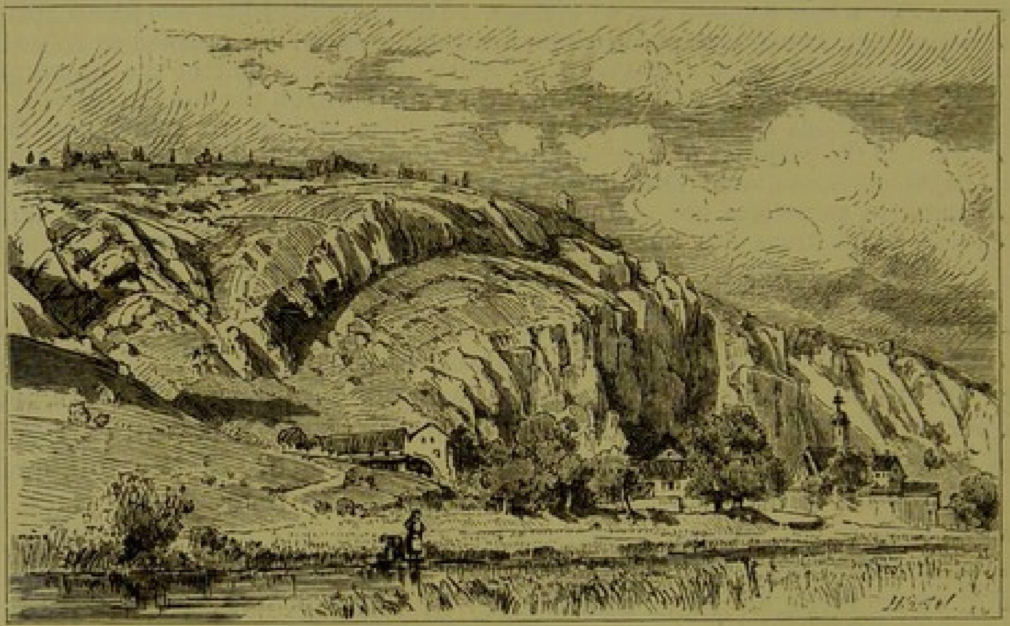
It may, however, be stated that Waldrich, in the year 1867, asserted and brought forward evidence to show, that the Salzbach, the Muhr, the Enns, and the Traun discharged more water than they received from the atmosphere in a given time. The great bulk of scientific testimony nevertheless goes to prove that more water is contributed to the earth by rain and snow, than the rivers can carry away; and the way in which the meteoric water penetrates below the surface of the earth demands a closer attention. We have already spoken of the experiments which showed that certain kinds of soil do not give access to the rain water to any great depth, and therefore are not calculated to collect meteoric water into springs; but if we examine a sandy stratum, we find that it will let the water run through it like a sieve, and reach great depths. The same thing may be said of rocky ground abounding in crevices, and of limestone. In certain parts of Cornwall it has been observed that the water rises in the deepest limestone pits soon after rain falls on the earth's surface; and without going so far afield, who has not noticed the dropping of water in deep underground cellars in times of heavy or it may be moderate rain?

The immediate connection between springs and the meteoric water can be best studied in the regions of limestone formation, such as the highlands of Altmühlalp in Bavaria, one of the most interesting districts of South Germany. No springs are found throughout this district, and only the water procured by melting the snow, or that which the rain pours through the cisterns of the houses, and in large water-proof pits or troughs, for the cattle, can be obtained. If there is a long season without rain, the inhabitants are compelled to have recourse to the neighbouring valleys, and drag up water for their needs at great cost and trouble. The open clefts of the limestone receive all the rain, and carry it down to the base of the rocks, where it bursts out as springs. The few wells which are found at different heights in the high lands, and which contain standing water, are enabled to do so by the presence of a deep substratum of clay soil, which does not admit of the waters passing through it. A similar state of things prevails near Paderborn, on the road to Cassel. Along the whole mountainous district only a few scantily filled springs are found, and they owe their existence to the presence of a substratum of calcareous marl. In the three villages of Busche, Egeringshausen, and Dornhagen, there is only one well eighty feet deep, whose presence must be accounted for in the same way. Even this well soon dries up in hot weather; and the districts are known by the name of the "dry villages," because of the almost total absence of water.

The capability of the ground to receive large quantities of water has been made use of at times for various practical purposes. Arago tells us that the low ground at Paluns, near Marseille, was once a marsh. King René had a number of holes or pits sunk in the ground. These pits still carry off the masses of water which would put a stop to all culture of the soil, and lead them to a porous stratum of earth at a certain depth below the surface, which allows them to reach, by its subterraneous channel, the harbour of Miou, near Cassis, where they appear as wells.

The river Orbe, in Jura, which rises in Lake Rousses, carries to Lake Joux more water than it can dispose of by evaporation, and yet the surface of the latter lake preserves a uniform level. The reason of this is that there are subterranean passages in the bed of Lake Joux, into which the water rushes and is lost. As it is of great importance to the inhabitants that these natural outlets should be preserved, for without their aid the houses and cultivated land would soon be standing under water, they are carefully watched, and new pits are opened as soon as it is seen that the water is not absorbed with the necessary rapidity. All that is then necessary is to sink holes of fifteen to twenty feet deep, and eight to ten feet wide, in the porous earth. These holes are called *entonnoirs*, and all the water swallowed up within them springs up again to the surface about a mile and a half from the northern end of the lake, and forms a fine spring, also called Orbe.

It is clear that if the theory be true, which ascribes the origin of springs to the conflux of meteoric water, no permanent spring can ever be found on the summits of mountains, unless it has been forced upward by the hydrostatic pressure of some higher column of water. This is so self-evident, that the opponents of the theory have sought for such springs eagerly upon the highest points. They succeeded in finding many at very great elevations, but a closer examination always showed that there were still higher levels in the neighbourhood, from which the meteoric water could descend. A spring on Mount Ventoux, called Font Feyale, was said to be found upon the highest point of the mountain, but it turned out afterwards that it lay 655 feet below the summit. The famous Hexenbrunnen (Witches' Spring), on the Brocken, has been often quoted as an example of a spring found on the highest peak of a mountain, and yet it is six and a half yards from the summit. It is certainly remarkable that a spring in a treeless district, and with such a shallow source flows unceasingly, and carries daily 1,555 cubic feet of water; but upon reflection, when we assume the half-diameter of the level which is above it to be only 500 feet, and the volume of meteoric water descending upon it yearly to be two feet high, taking for granted that the porous soil carries the whole quantity down to the granite strata below, the spring would be able to furnish more than 4,016 feet daily. But the phenomenon fails to excite further wonder, when we remember how early in the year snow falls on



View at Altmühlthal, Bavaria.

the Brocken, and how long it lies; also that the summit is almost constantly enveloped in cloud and mist, which keep the thick mosses growing down to the edge of the spring wet with heavy drops. It is no wonder, then, that the Hexenbrunnen is perennial, or very nearly so; it has been known to fail at rare intervals, as for instance in the summer of 1876.

Here then, as almost everywhere, enquiry leads to the result that the meteroric water is sufficient to supply the spring; but there are yet instances in which certain difficulties are presented. At Ochsenkopf, for instance, in the pine mountains, there is one, the water supply of which is difficult to explain. Ochsenkopf is a granite cliff, overgrown with tall pine trees and a very luxuriant moss. Only the upper plateau is barren, and covered in part with lichens. The moss is always moist, and in summer time it is so wet that the traveller finds himself wet to the ankles in passing through it. About eighteen or twenty feet below the upper plateau is a little cave formed by a confusion of granite *débris* heaped together. The floor of this cave is covered with water, to a depth that has not been ascertained, and a constant rippling is heard down the clefts. The inhabitants declare that this streamlet is always flowing, and they believe it to be the source of the Maine. The level above the spring is certainly too small to be able to carry down sufficient water to keep up the supply.

It was suggested that the rain water was carried by the mosses to the spring, but the idea was quite untenable. But if we consider that the Ochsenkopf is a mountain chain of nearly four miles long, and that the spring is not exactly on the highest point, there seems reasonable ground for supposing that it can yet be supplied by meteoric water. There is, however, a grotto in the island of Pantellaria, from the floor of which ascends a moist vapour to the vaulted ceiling of the rock, from which it drops down again like rain, and forms a perennial spring, thus proving that in certain cases springs may owe their origin to the downfall of evaporated water. At Stromboli, also, in a stratum of scoriæ and ashes, rises a spring of fresh drinking water, which does not fail even when those below it on the mountain-side dry up, as they do at least once in the year. The bare curve of the mountain above cannot supply this spring with atmospheric water, and it must therefore be supplied by distillation from within. And on Calogero mountain, on the sea coast of Sicily, opposite Pantellaria, vapours rise from a grotto, fall back in drops, and form a spring.

The famous Abbé Paramelle furnished striking proofs of the meteoric origin of spring water. In the year 1818 the Abbé was vicar of a parish in the department of Lot. Here he found the eastern side of the country well watered, while the western (limestone formation) suffered terribly from want of water. The Abbé's sympathy and curiosity were alike roused, and he began to investigate the matter. He found after two years' study, specially devoted to the neighbourhood of the rivers Lot and Dordogne, that the numerous springs in the low-lying levels did not owe their origin to the rocks from which they issued, but to the downfall of meteoric water which descended on the plateau, and penetrated beneath the soil. Starting from this point of view, Paramelle journeyed through the high lands, looking for traces of these subterranean streams, but for a time with no success. He then began to study the geological character of the rocks from which the springs issued, giving special attention to the springs flowing naturally out of the ground. He asked himself what were the characteristics of the ground they affected, why they were so unequal in their water supply, why they were found in some localities and not in others, and what laws produced the existence and course of the visible streams. It was in this way that the Abbé was led to form the theory of subterranean streams, and the moment was now come to test it on the limestone formation, and to bring to light its hidden watercourses. Here he began by examining the watercourses found on the river banks, and tried to trace them up to their probable source. He became convinced of the connection and course of a subterranean system of streams, even in the limestone formation, and after nine years' patient research and experiment he had traced out in theory the line described by every spring, and even its depth and volume. The practical results of his theory were incalculably great.

In the year 1827, he presented to the General Council of the department of Lot a short treatise containing an exposition of his theory, accompanied by a letter, in which he offered to go to every village, or private individual who desired his services, and without remuneration to superintend the necessary works, and he asked the prefect to vote a grant of money sufficient to cover half the expenses, on condition that the community which was to reap the benefit should defray the other half. He said also that his theory was by no means infallible, and that he should doubtless make many mistakes; but his faith in it was so great, that he could guarantee that two out of every three experiments would be successful. The General Council took up the matter favourably, and placed 600 francs at the prefect's disposal.

In the following year, circulars were issued to the communities which were most in need of water, calling their attention to the Abbé's generous proposal. Only eight, however, were willing to subscribe any money, for the general impression was that it would be impossible to find any springs in the limestone plateau. The Abbé went to these eight villages, pointed out the position of the spring, with its depth and volume, but only five out of the eight began to sink according to his directions. In every case the success was beyond all hope. One of these five springs was the great Recamadour spring, which was pronounced to be large enough to supply the whole departmen with water. The joy of the neighbourhood was beyond description.

After this first brilliant success, Paramelle was invited to meet the prefect, to explain his theory, and discuss the means of applying to all the districts suffering for want of water. This was done at a meeting on September 1st, 1829. Paramelle, commenting on his first experiments, warned them not to look for such results always; but assured them that at least two-thirds would succeed. "And if only half succeed," was the reply, "you will have rendered incalculable service to the department." The General Council expressed the hope that the Abbé's theory might be successfully tested in other places where the water supply was insufficient, and where in hot seasons there was scarcely enough to prevent the domestic animals from dying of thirst. The Abbé's unselfishness was generously commented upon, and his readiness and zeal in pointing out the spot where the sinking was to be begun, and in assisting the work during its progress, were also mentioned with praise; the great services which he had rendered to the department were met, in short, with their well-earned recognition; his theory was pronounced to be in accordance with the laws of physics, and a vote of eighty pounds was passed to indemnify him for his personal expense, and to assist the communities who were willing to profit by his art.

The Revolution roughly interrupted the Abbé's beneficent schemes, and yet in 1831 the subterranean watercourse had been found out in seventeen localities, and in sixteen others its probable place had been indicated on the surface. The General Council therefore decided to allow the Abbé ten francs for every well brought to the surface, and bound over the authorities of every community where the presence of a well was indicated to complete the necessary sinkings within a year from the time of its having been pointed out. After this time the Abbé went to every place where he was sent for, and as his first thirteen experiments were successful—he failed to discover water in the community of Cartunac—the fame of his skill spread rapidly from place to place, and soon reached beyond the boundaries of the department. Public confidence increased day by day, and the Abbé was obliged to protest vigorously against the infallibility ascribed to him, and to refer continually to the few instances in which he had been unsuccessful. His disclaimers were of no avail; the failures were forgotten and lost in the number of his successes, which the public delighted to magnify and exaggerate.

Paramelle's fame now began to arouse general attention throughout France. He was inundated daily with letters and enquiries, and finally thinking that he could do more good in supplying the poor and thirsty communities with water, than by remaining at his post, he wrote to his bishop, and laid the case before him. The bishop acceded to his request, and allowed him to leave his parish, so that the Abbé was now able to extend his help to the departments of La Corrèze, Aveyron, and Dordogne. He was almost everywhere successful, and besieged by enquiries from all quarters. During the first three or four years of his labours, the untaught crowds, who knew nothing whatever of physical science, were inclined to ascribe his wonderful successes to the result of a miracle; and the wildest reports as to his powers were spread abroad and eagerly believed. The Abbé meanwhile went on his way with quiet industry, followed by the blessing and respect of his countrymen. After some hundred attempts had shown that the successes far outnumbered the failures, the Abbé was sent for in course of time by forty departments, and even made excursions into the countries bordering on France. The invitations addressed to him from the departments rose from 300 to 1,000, 1,500; at last more than 2,000. In departments where the formation of the ground was favourable, he was able to point out a third or fourth part of the desired wells, but in unfavourable localities only an eighth.

From the year 1832 to 1853, Paramelle made his yearly journeys from the 1st of March to the 1st of July, and from the 1st of September to the 1st of December; working, with the exception of Sundays and festivals, from sunrise to sunset, with a rest of two hours from ten to twelve o'clock. He always went his rounds on horseback. In his sixty-fourth year his failing health obliged him to discontinue his travels, and devote himself to writing and working out his theory.

The greatest difficulties have always been presented by the presence of wells springing up in oases and in desert wastes. Primeval caravan tracks lead to them, and the Bedouin leavesthem with reluctance to plunge into the surrounding sands. Where does the water of these wells come from? Has it been left behind by the water which once covered the whole bed of the desert, or is there an ocean of sweet water flowing below the stretches of sand? Scientific enquiries are especially roused by the wells found in the great North African desert of Sahara, which is generally accepted everywhere as the typical sandy waste.

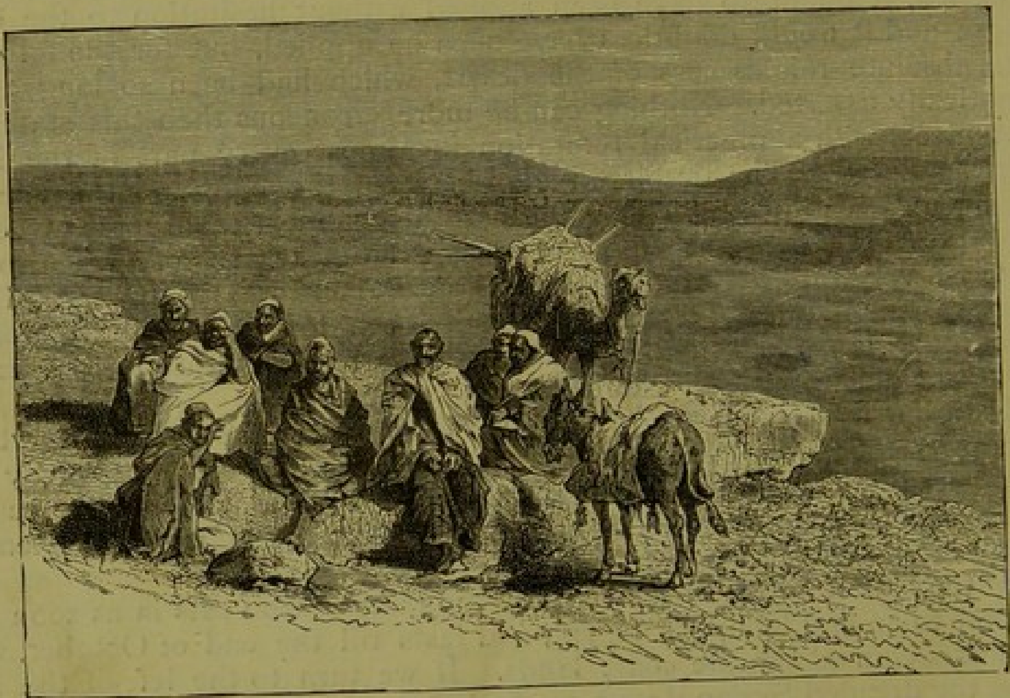
It cannot be denied that at some long distant period the desert of Sahara was partially covered by the ocean. And we shall describe later on how the country gradually became more and more desolate, as the process of desert formation, when once it has set in, cannot stand still. However great the spread of this desolation may be, and however much the water supply of Sahara may have diminished in the course of ages, the clouds of heaven yet visit the sandy plains with rain, and the water which wells up through the earth and fertilizes the oases is nothing but rain water, like that of other wells.

It is extraordinary that this truth should not have been perceived earlier; but, as a matter of fact, the most absurd theories, bidding defiance to every principle of hydrostatics, were put forward to account for a phenomenon which is certainly not without analogy. It was a long time, it is true, before scientific men agreed that the water of our rivers and springs owed its origin only to the rain which fell on the river basin; but when once this truth was established, it ought to have been applied without hesitation to the desert springs; and it would doubtless have been so applied, but for the false idea of the absolute rainlessness of the desert, which had been so long and so dogmatically asserted. Nothing can be more erroneous than this statement, and it meets with a practical refutation in almost every part of the North American desert. The desolate region between the Nile and the Red Sea is by no means rainless. The great natural channels of Myata, in central Egypt, preserve a constant supply of water even in seasons of great drought, and it is a very rare occurrence for these natural cisterns to be dry. In the winter season, volumes of water occasionally rush down them, and the barren district round looks like the bed of a foaming torrent, the waters disappearing, however, as quickly as they came.

Heuglin, in his journey through the Barbary desert on the 7th of September, 1864, was overtaken by a thunder-storm, accompanied by rain, which speedily changed the camping ground into a lake fed by rushing mountain torrents from the south and east. Before the raging of the elements had subsided, night broke over the scene.

In the mountain land near Barbary the rainy season sets in as soon as it has come to an end in upper Egypt, and lasts till the end of October, when the rains begin along the coast lands. If we turn to the left of the Nile, toward the dreaded Syrian desert, we find that even here the sands are by no means rainless. The members of Rohlf's expedition were much astonished by being overtaken in the midst of the barren waste by a downfall of rain which lasted for forty-eight hours without intermission. This happened in the month of February, and extended to the oases of Farafrah, Chargeh, and Dachel; no rain falling in Sivah, Beharieh, and the valley of the Nile. The height of the rainfall was one-twentieth of an inch. This rain seemed to make no impression upon the inhabitants of Dachel, and was said to fall with equal violence about every two years. Any one who knows what a deep impression is made by a fall of rain in regions where it is of very rare occurrence will be at once convinced, by the indifference of the natives of Dachel, that rain falls in that place much more frequently than was generally believed. Professor Jordan, who accompanied the expedition, speaks of two other occasions on which there was a moderate fall of rain. "On the 25th of February, 1874," he says, "after we had left Sirtah, it rained slightly for several hours, the rainfall amounting to 0·9 of an inch; and on the 4th of March, in passing through Bahr-bela-ma, the earth was wet with rain to a depth of half an inch. Sometimes also we observed a fall of dew." Moderate rain is known to have fallen at Sivah, and a few days' journey to the east of that town, in 1819 and 1820. As to Fesan, Rohlf reports that although it does not lie within the zone of tropical rains, yet at times there are heavy downfalls of such violence as to melt the huts, which are built of clods of earth containing a quantity of salt. The inhabitants are by no means glad to see these rain-storms approach, for they can always find water at a little depth below the surface; and as the palm trees require no artificial watering, it is to be supposed that their roots are within reach of the surface of the water. In March, 1866, Rohlf was overtaken by rain on his journey from Mursuk to South Fesan, the storm lasting for a day and a night, and compelling the travellers to interrupt their journey.

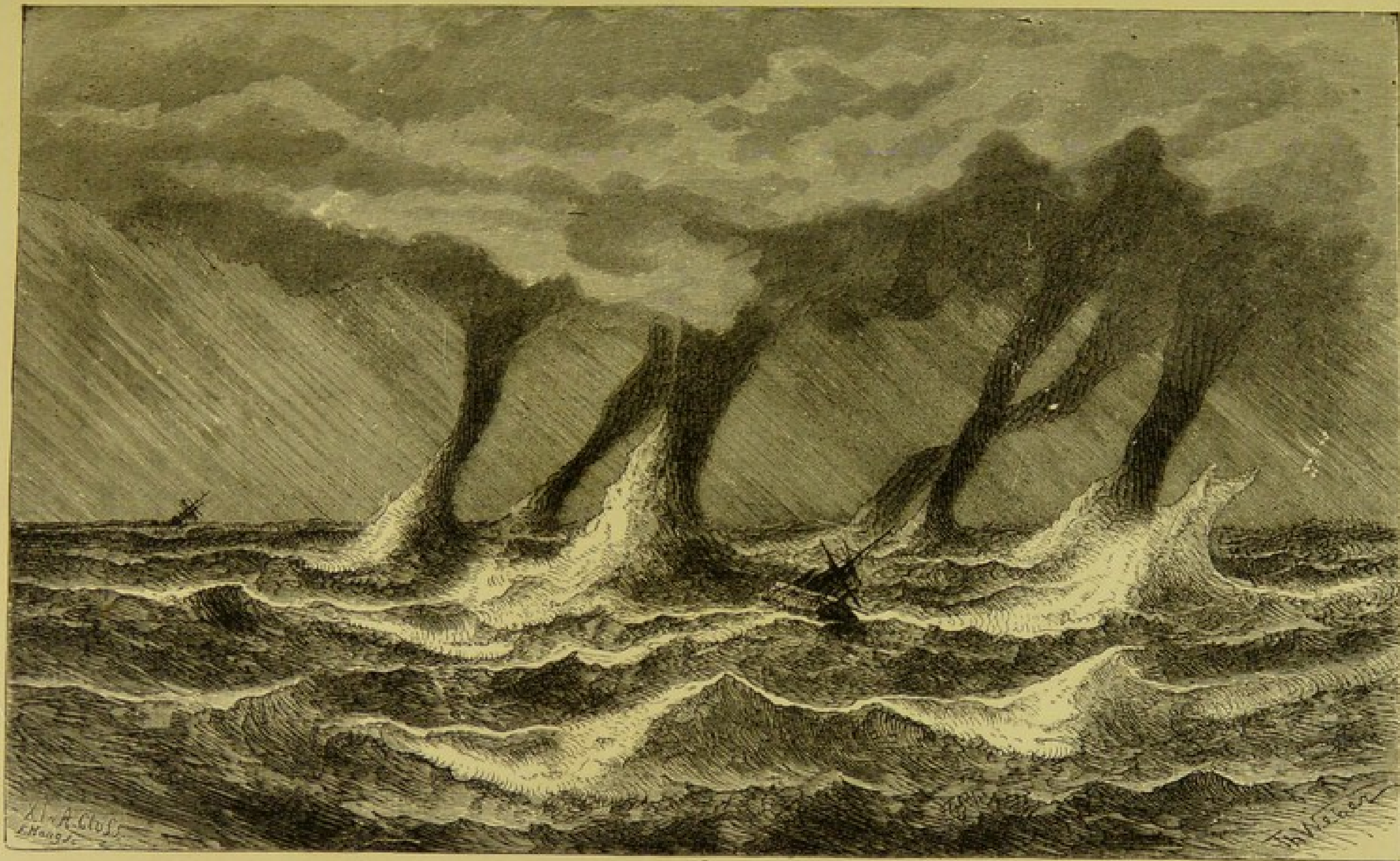
Heavy rains are not unknown to the westward of Mursuk, so that a strong current flowing from the west pours through the shallow channel of



A HALT IN THE DESERT.

Wady Aberdjusch. Places were seen where shortly before the stream had made itself a bed five feet deep, and the traveller was told that so much rain had fallen lately that the streams were full of water. In Wady Elauen the rain-storm had uprooted bushes and brushwood, and left behind it a channel a hundred feet long and fifty wide. At a little depth below the surface of the valley good drinking water was obtained.

No rainfall was observed in the oasis of Kawar in April, 1866; but in May there was a tempest on several occasions; in June, rain and tempest on the same day, and three thunderstorms without rain. The average temperature in May and June, taken at Schimmedru, are the highest known, these months being the hottest in the year. The relative humidity of June amounted, on an average, to 28·5°. In April, when the sun culminated south of the zenith, north winds set in; when in the zenith, south winds, but calms prevailed. In June, when the sun was in the north quarter of the heavens, east and south-east had the upper hand. According to other observations, south and south-



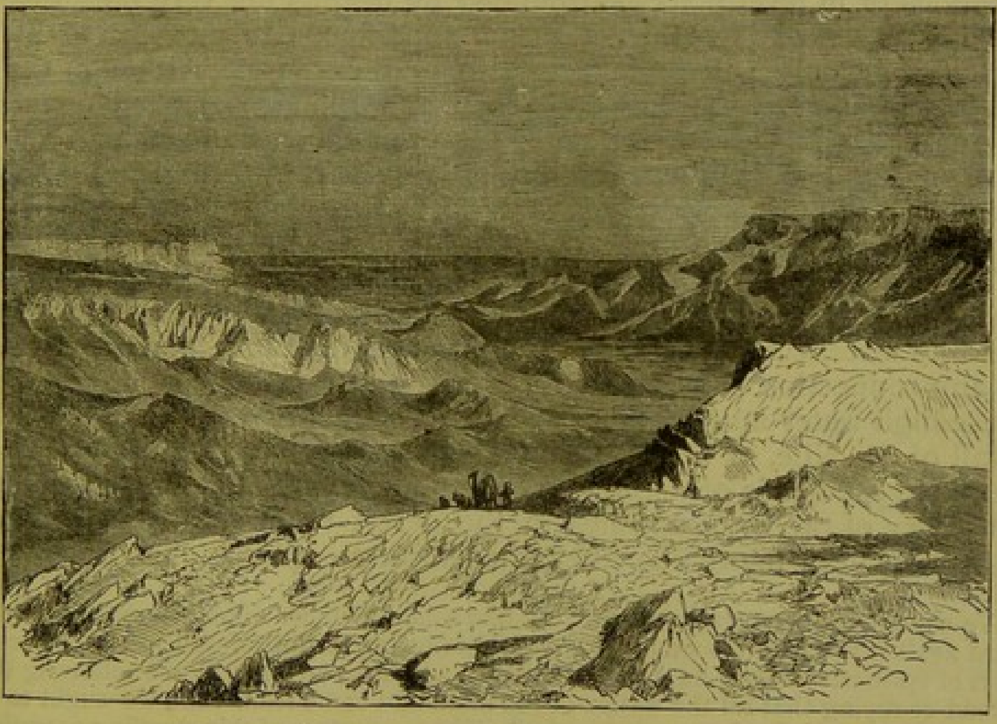
WATERSPOUTS.

east winds prevail in June, July, and August, bringing rain with them, and always being accompanied with a cloudy sky.

Near to Kawar also Rohlf found that rain and rain clouds always came from the south-east towards the end of June, and on the 5th of July, 1866, he and his companious were saved from death by the sudden outburst of thunder-rain near Agadem. This friendly storm came with heavy black clouds from the south-east.

On his march through the desert to Bilma, Barth saw the ground moistened by a shower of rain which had fallen the day before; another proof, if proof were still wanting, that the common idea of the absolute rainlessness of the desert is erroneous.

We know less of the rainfall in the western regions of Sahara, but to the south of the Atlas the rainfall in January and the first half of February



Approaching the Oasis of Dachel.

extends inland to 10° east long., in a diagonal line parallel to the Atlas as far as the oasis of Figgig. In the oasis of Tuat and the adjoining regions there is no lack of rain, although the rivers there draw their waters in part from the French Tell. This water, says Rohlf, although it does not come down to Tuat in a direct course, we are nevertheless forced to assume that it flows on under the sandhills towards Tuat, rising so near to the surface that the inhabitants are able to carry it on by means of the Fogara, and to make use of it for agricultural purposes. In support of this view we have first to remember that all Fogara have a direction from north-east to south-west; secondly, that they swell visibly after heavy rains; and, thirdly, that there is never a sufficient rainfall in this part of the desert to produce watercourses of such size as those formed by the Fogara.

The examples given above could be supplemented by many others; but they are enough to prove that the desert is by no means rainless, but that sufficient meteoric water descends upon it to account for the presence of the springs. We might be inclined to believe that the rain would not be sufficient in amount to keep up the springs. Such an impression, however, would be most erroneous. The rain which fell in the Libyan Desert during Rohlf's expedition, and that noticed during the same period in the oases of Farafrah, Chargeh, and Dachel, although it gave only half an inch in height, yet if only one-seventh penetrated the ground, it would amount to 4,320,000 cubic feet to the square mile, enough to feed ten wells for a whole year with a daily water supply of more than 1,080 cubic feet.

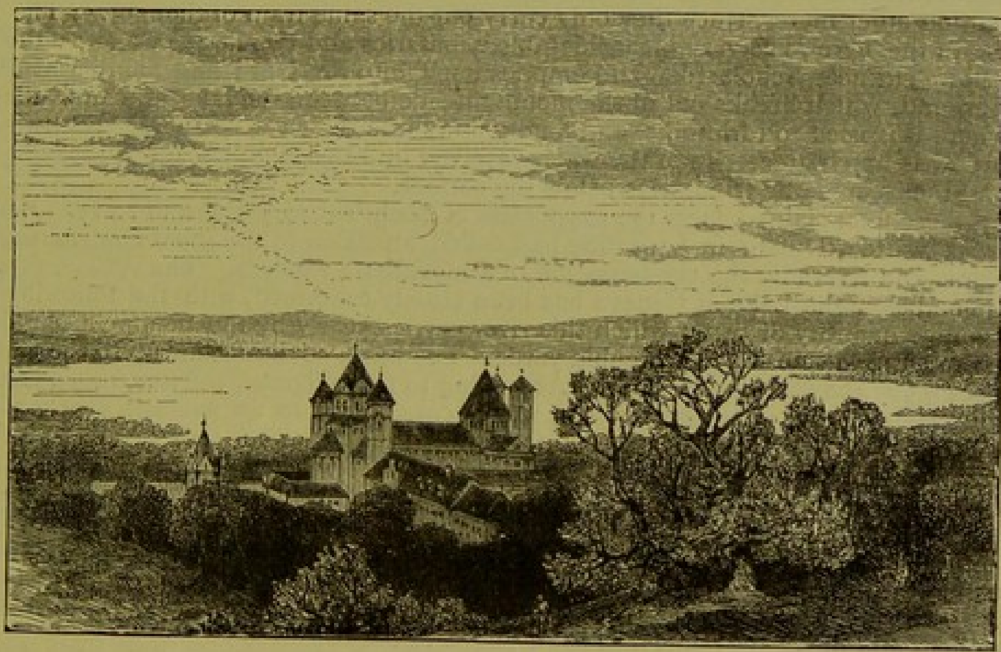
If, then, this view is adopted, and the springs of the desert have their origin in the same causes as the rivers and springs of the cultivated regions, it is clear that they can only be found in circumstances analogous to those which produce the latter, and such is known to be the case. There is no spring either in the desert or upon an oasis which is situated upon ground higher than that which surrounds it. All springs and all oases are found either in depressions or in level places surrounded by heights not very far away. This is such a universal law, that it seems superfluous to establish it by many instances, one only will be sufficient for our purpose. Although the desert of Tintumna, intervening between Tchad and Bilma, is looked upon as one of the most terrible wastes of sand, yet even there, close behind the rocky heights of Agadem, is a depression containing a fresh spring, and used for the general camping place of caravans. Near to this place Barth noted a moderate fall of rain on the afternoon of July 5th.

The old fable of a subterranean sea flowing below the desert sand is nothing but a phantasm of the brain: there are no subterranean waters, except such as we find necessary to support ordinary wells in other places; there is not even any connection between the Nile and the desert springs; not so much because high water in the wells appears to be quite independent of the rise and fall of the Nile, as because such a connection is demonstrably impossible from the hypsometric configuration of the land. We may, however, consider the mystery of the living springs in the desert to be unveiled, and we find that here, as in so many like cases, the simplest explanation is the true one.

We cannot omit to mention, in a work like this, a number of objections recently brought forward against the theories we have been defending, as to the rainfall being the source and support of springs. Volger has lately published a treatise advocating the following thesis:—"Instead of saying that all the waters of the mainland come from rain, we ought to say that no waters of the mainland come from rain." The supporters of this startling assertion point out the very slight depth to which rain can penetrate the earth's surface. The resistance offered by the adhesion of vast spaces of richly cultivated land, they tell us, becomes at last an impenetrable barrier to the advancing water, as can be seen by the damming of any river. In certain parts of Holland, the Rhine flows more than three yards above the ploughed land behind the dikes, so that from the land the spectator looks up to the sails of the ships above him; and from the river he looks down upon the steeples and windmills of the land; while the outer wall of the dike is not even moist. In many countries mines are worked far below the surface of the sea, and yet there is no greater permeation of water than in those worked upon the highlands. Not a single drop of Thames water filtered through upon the workmen engaged in making the tunnel; when the breach came, it came all at once.

Moreover, we are told that, on the whole, evaporation is greatly in excess of the rainfall so that there is no rain left to form wells and springs; and that the source of wells and springs must be found in the aqueous gases rising by evaporation from the ocean, and carried across the continents by atmospheric currents. This watery gas is condensed in underground channels protected against all organic impurities, and becomes by that process pure *aqua distillata*, receiving, indeed, certain mineral substances according to the construction of the strata through which it passes and where it is lodged, and possessing the great advantage of retaining within it all its carbonic acid contents. The central dogma of this new theory is that the water of our springs, brooks, and rivers, instead of penetrating the earth drop by drop as a fluid, enters it as vapour, and is condensed below the surface. In saying this it is not denied that an outburst of tropic rain, or any heavy and continuous shower which we can see falling from the clouds into the spring, often occurs to swell the brook or river ; in such a case the turbid *superterranean* fluid is undoubtedly water, and not vapour. But such rainfalls pass away in the course of a few hours, leaving the brook quietly flowing on. And if it is admitted that water, as such, canno :penetrate below the earth's surface, there is no third alternative, for it would be still less able to do so under the form of snow or ice.

A number of facts have been brought forward in support of this theory. If, says Mohr, we look upon some tributary of the Rhine which brings down no glacier water, such as the Moselle, the Main, or the Neckar, we find that these rivers contain more water as they approach their mouth : and if we turn to the larger tributaries of the Moselle, the Meurthe, the Saar, and the Sauer, we cannot tell whence they procure their water, since they have no tributaries above ground. Now we find that rivers and brooks below their level are kept up by water flowing down to them from the surrounding land. This water, of course, stands higher than the river, which is the lowest channel of the country ; and as water always condenses below ground, it also must flow downward, as it does throughout the whole river basin, first into the tributary channel, and then with the principal stream into the sea. In the dry, hot summer of 1846 no rain fell for four months, and yet, although the rivers were low, they flowed on without interruption. There was no possibility of their receiving any supply from



THE LAACHER LAKE.

above ground ; the brooks, of course, received only ground water, and the river received the brooks and the ground water which entered it on both sides along its whole course. A certain place in the mountains lies several hundred feet above the river, but its well is found at the ordinary depth, that is, far higher than the river. Thus the wells in the Rhine valley are higher than the level of the Rhine, and flow down to it. Accurate measurements have proved this.

The Laacher Lake at Andernach is the immense crater of an old-world submarine volcano, whence arose the great quantity of tufa and pumice stone which is found spread over the adjoining neighbourhood. Its surface lies 917 feet above the sea, and 750 feet above the Rhine. The deepest point of the lake lies 182 feet below its surface, that is, 735 feet above the sea. The mountain near is of clay slate, of which the part torn away has furnished the material of the deposit of tufa. Only a narrow margin is found round the greater part of the lake between it and the mountain, while on the south side the mountain retreats so as to leave a wide plain between its base and the edge of the lake. The country round is richly wooded. The lake has no visible natural tributary, and had formerly no outlet for its waters. In the twelfth century an outlet was dug underground by the abbot of the monastery, to protect the building from the dangerous risings of the lake's surface. In more modern times the outlet was dug lower, and thus several acres of ploughed land were gained. The surface of the lake measured formerly 956 acres, and now only measures 836. The stream sent out of the lake is let to a miller, and used by him to turn a mill. We see then here a lake more than seven hundred feet above the Rhine, with no visible tributaries and a considerable outflow. Even in the heaviest rains no water falls into the lake, for it is all caught by the thick foliage of the surrounding woods, or absorbed in the loose porous soil. Notwithstanding the enormous amount of evaporation, the ground water is enough to cover the outflow used by the mill. The slopes descending to the lake, including the level shore, measure 1,620 acres; that is not twice the lake's surface of evaporation, but in reality the water flowing down the slopes never reached the slopes at all, but was evaporated from the land.

The case is similar with the so-called mere of the volcanic Eifel. The mere of Gillenfeld is nearly circular in form, and surrounded by high woods. The evaporation is in excess of the rainfall, and yet the surface is almost uniform in level. This mere has no visible tributaries whatever. The Weinfelder mere is 582 yards in diameter. It has steep barren walls of porous tufa, which can absorb and retain large quantities of water. The water never flows out of the mere; its lowest part is 1,200 feet above the sea. This mere is also an extinct crater.

The pool at Mosbruch is 1,600 feet above the sea, and measures at its greatest and least diameter 980 and 780 yards respectively. It is shut in on every side by meadow land and turfy moors. The Trierbach flows out of it on the north side, and empties itself into the Ahr; while the Ues flows out from the west side of the pool toward the south. Bad Bertrich is situated on the latter stream, which flows by Alf into the Moselle. This pool at Mosbruch then has no tributaries; but, on the contrary, it sends out two considerable streams. We will not mention other meres, since they only carry out the same train of thought. The lake of Aachen, in the Tyrol, has very inconsiderable tributaries and two large outflows: the Aache, which flows out near Scholastika, and empties itself into the Isar; and another at Pertisan, below ground, which breaks out of the mountain-side between the lake and the valley of the Inn, where it is used to turn mills, and finally flows into the river. In all the Swiss lakes the outflow is much greater than the water received into the lake, because the lakes are fed along all their course by tributaries below the surface.

All these unexplained facts the supporters of Mohr's theory claim to solve. Before this essay was written, Dufour in Lausanne had called attention to the great contributions given to streams and rivers by the condensation of atmospheric vapours. The volume of water in the Rhone below the Lake of Geneva has been closely examined, with the following results. The average quantity of water which this river carries yearly by the point chosen for observation amounts to 12,012,736,320 cubic yards. The basin of the Rhone up to the same point measures 9,505,166,666 square yards. According to these figures, the amount of water, even after throwing off the evaporated water, would correspond to an average yearly rainfall of one and a quarter yard in height, taking for granted that the river receives all its water from atmospheric sources. Now it is shown by direct observations that the rainfall is on an average 0·8 of a yard in the year, and this includes the water which ascends again in evaporation. As the supposition that all river water is due to the descent of meteoric water has been long established throughout all Europe, nothing remains in reference to the Rhone than to assume that it has some other source from which a part of the rainfall reaches it in another form. This source, according to Professor Dufour, is found in the condensation of the atmosphere and in the ice-fields and snow-plains of the Alps.

Something analogous is seen in the familiar experiment of exposing cold glasses to a warm, moist air. A glass vessel five and a half inches in diameter, filled with a mixture of snow and salt was exposed for an hour to the open air. The relative moisture was between 0·66 and 0·70. At the beginning of the experiment, the glass and its contents weighed 1 lb. 7·7 oz., and at the end 1 lb. 7·8 oz. Although the air was not quite filled with vapour, yet 1 oz. was condensed upon the cold sides of the glass. There is, indeed, no doubt that direct condensation of watery vapour has the effect pointed out by Dufour. This fact is of great importance, and greatly lessens several difficulties arising from the old theory, which were by no means removed by that of Volger and Mohr. Nowak, indeed, considers *their* theory the least defensible of the two, and finds himself called upon to suggest a third. According to this new hypothesis, there exists a hollow space between the earth's crust and its central mass. The surface of this mass is asserted to be of mineral substance in a state of fusion. The water of the lakes and seas percolate through rifts and fissures of the earth to the fiery centre; there it is changed into steam, which is condensed against the inner surface of the earth's crust. If this part of the theory is accepted, there is little difficulty in accepting what follows,—namely, that this condensed water is collected in all the concavities of the earth, and gradually is collected into large masses. Based on these two premises, the subterranean masses of distilled water below the mainland and the islands, together with the high temperature prevailing in the hypothetical hollow space between the earth's crust and the centre, and the immense pressure of the vapour, would account for most of the phenomena of our springs. According to our own opinion, while we admit that certain phenomena connected with various springs seem to suggest explanations like those put forward by Volger and Nowak, we are not inclined to admit that either theory, taken as a whole, is capable of overcoming all the difficulties of the subject so satisfactorily as to render it more probable or more deserving of acceptance than the older theory.

The water which penetrates the soil from the earth's surface is checked, as a general rule, when it meets with a stratum of non-porous soil, such as clay or marl. It then follows the incline of the impervious stratum, and is either carried down to the depths below, and collected in a subterranean reservoir, or to the outer slope of the hill, where it comes to light again as a spring.

Forests and woodland districts have much to do with the quantity of water found in springs. They are, as it were, regulators and conductors of the atmospheric rainfall, forcing the rain to flow gradually to the springs, and filtering it through the foliage, instead of allowing it to pour in sheets from the heights. The beneficent influence of a due proportion of wooded land is also shown by its collecting moisture and checking too rapid evaporation, and by its piercing the soil with its branching roots, and so preparing a freer course for the entrance of the waters.

Many examples have been recorded of the disastrous consequences caused by cutting down forests which supplied and fostered springs or brooks. The classical Skamander, near the plains of Troy has dried up, from this cause alone. In Pliny's days it was a navigable river; but a modern traveller looked for it in vain, finding neither the river nor the cedar woods of Mount Ida, where both the Skamander and the Simois had their sources.

The following particulars are given by Boussingault on the same subject, during his sojourn in Bolivia. Not far from the coast of Venezuela, he writes, lies the fertile province of Aragua. High hills close it in on every side, so that the mountain streams which flow down into the valley find no outlet toward the sea, and, collecting together, form Lake Tacarigua. At the beginning of the present century, Humboldt visited this lake, and found it gradually decreasing in depth and extent. The loss had been going on for about thirty years, and none of the inhabitants of the district could assign a reason for the occurrence. Humboldt at once ascribed it to the cutting down of the neighbouring woods, which was being carried on to a very great extent. In the year 1822 this lake had risen considerably, and tracts of cultivated land were under water. The change was explained by the War of Independence, which had put an end to all agricultural processes for twenty-two years. The population diminished, fields were untilled, and dense woods covered a large extent of the valley. A clearer proof of the influence exerted by forest land on the water supply of a country could scarcely be found.

In 1826 only a few huts belonging to negro slaves were standing in the mountainous district of Marmato, famous for its mineral wealth. Four years later the face of the country was so changed that numerous works were opened, and there was a population of three thousand souls. It was found necessary to cut down a great deal of the surrounding timber; and although the clearing had only gone on for two years, the water used for the machinery of the works was already showing signs of decrease, notwithstanding the greater rainfall which was recorded in the second year. The inhabitants of Dubate, in New Granada, lying between two lakes, report the gradual sinking of the waters, and further investigations traced the cause to the uprooting of extensive woods in the neighbourhood; and at the foot of a mountain in Ascension Island a fine spring was dried up from similar causes, breaking forth again when in course of time the mountain slopes were once more overgrown with trees.

The spring water conducted by the Romans from Etuvee to Orleans is now completely dried up; and a brook flowing to the east of the town, and emptying its waters into the Loire, no longer exists. This brook contributed in no small degree to the preservation of the town when it was besieged in 1428; it was of sufficient force to turn mills, and has only been lost by the cutting down of the trees which formerly grew on the same side of the town. In consequence of the continued uprooting of the surrounding woods, the municipal authorities find the wells in the town gradually drying up, and are obliged to get their supply of drinking water from the source of the Loire, at a cost of £12,000.

In mountainous districts, the cutting down of the trees sometimes promotes the breaking out of mountain streams, as is often noticed in the Alpine ranges. If there is much vegetation found upon the mountain-sides, the roots form a kind of net; but if the trees are cleared away, the force of the torrent carries down the rich soil, and hollows out channels which widen more and more, and at last become the bed of a permanent stream. The woodland and bushes of the declivities offer manifold resistance to the waters trickling down; they turn them aside, and distribute them over a larger surface, while the roots absorb a large quantity of moisture, which makes its way to the valley, and breaks out there in the form of springs.

Different Kinds of Springs.

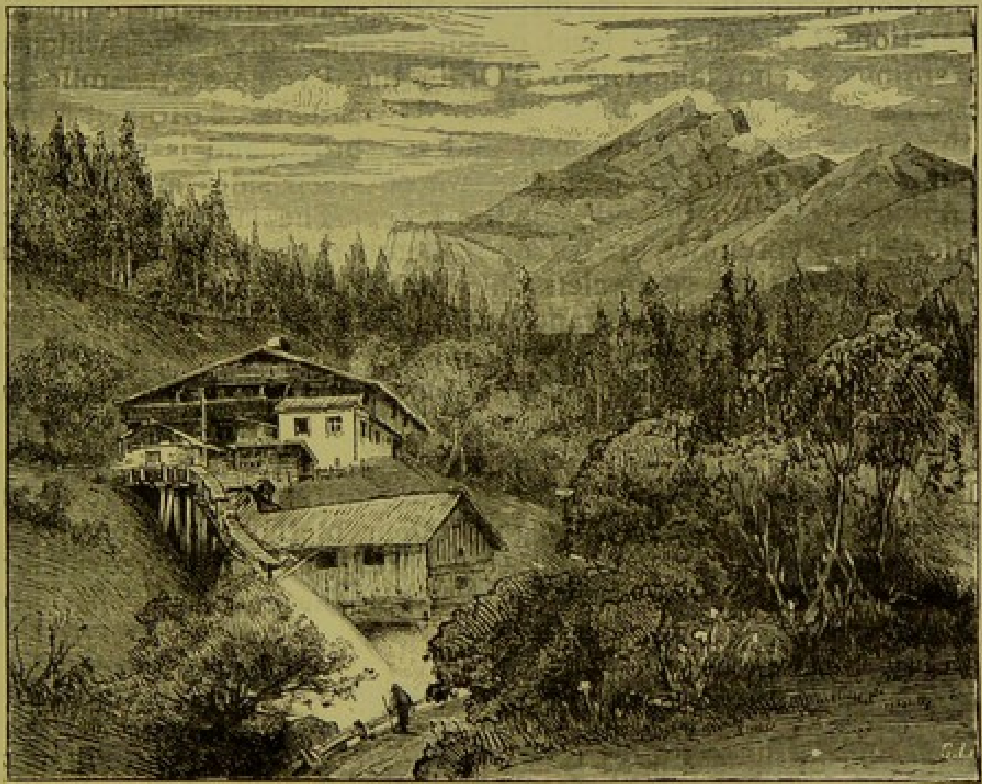
Springs can be classified in six divisions,—namely: 1. river springs; 2. springs formed by sunken streams; 3. springs formed from lakes situated in high levels; 4. glacier springs; 5. mountain springs; 6. deep-seated or mineral springs.

1. The river springs contain the water flowing from the neighbouring rivers, and reaching the spring by filtering through the sides of the river bed. On digging in the Rhine valley, where the river begins its lower course, a stratum of loamy clay, from four to eight feet deep, is first encountered below the surface; and this stratum is almost or altogether impervious to water. At a lower depth sand and breccia are met with, and, according to the evidence of the well-sinkers, the latter strata continue to unknown depths. The Rhine is therefore enclosed by these strata, and its course flows through them; so that through the whole extent of the Rhine valley, as far as the sandy strata continue, deep sinkings may be made. The water enclosed within the strata of sand and breccia is called bottom-water, and under certain circumstances it may exceed in quantity the river water flowing on the surface.

The springs formed by sunken streams are found in districts where brooks and rivers flow through a cracked and perforated soil. In this case much more water is absorbed than is the case with a sandy stratum. If the perforated strata extend to a considerable depth, enormous quantities of water sink in, and there are cases when the whole river has disappeared. The greater the force and volume of the river, the farther it will be able to flow over the perforated bed without being absorbed within it. After heavy rains, the place where the river sinks is therefore carried forward, and in times of drought it is found farther back, and the sinking waters come to the light as springs in some other place. The connection between the disappearance of river water and the creation of new springs has not escaped popular attention. In the neighbourhood of the Teutoburger forest, many legends exist, according to which anything dropped into the brook at the place where it sinks below the surface, comes to light again on the other side of the mountains, where the springs break forth from their base. We are told that a handful of flax thrown into the Ellerbach at Dahle is seen upon the surface of the Paderborn springs three days afterwards; and that when flax is steeped in Dahle, the brewed beer turns out badly in Paderborn. Also we hear that chopped straw scattered in the basin below Neuenbecken reappears in the springs at Lippe, and that two ducks which were carried along by the sinking waters at that place emerged again at Lippe after a few days. There are stories of a lawsuit carried on in former times between the proprietor of the river-basin of the Alme near Erdbeerenburg, and the Abbess of Geseke, on the subject of cutting off the plentiful supply of water in the spring of Aeskerf by stopping up the holes in the Alme.

Unfortunately the truth of all these stories in turn has been denied. Experiments have been made by dropping chopped straw into the Becke, but not a trace of it was found in the spring at Lippe; and although the connection between the water which sinks into the chalky marl of the mountains and the spring which breaks forth at its base cannot be doubted, it is nevertheless highly improbable that the subterranean waters flow in an uninterrupted channel, so as to allow of substances being carried along their surface for any great distance. On the contrary, all the evidence tends to show that the water sinks between the fissures of the rock, is collected into caverns, and forms an extensive reservoir, from which the contents flow out down the inclines of the rock, and break out into springs.

The Aache affords an interesting example of the connection between a spring and a river flowing over perforated soil at a great distance off. Between Immerdingen and Möhrungen, where the upper Danube flows over the perforated country of the White Jura, which abounds in clefts and fissures, the entire volume of water wholly disappears in seasons of drought, leaving the river bed dry as far as Mohrungen ; while the spring at Aache, about 12,025 yards to the west of that place, and belonging to the Rhine basin, looks like a lake rather than a spring,



Outlet of the Lake of Aachen, in Unterinnthal.

so great is the amount of water it contains. In order to establish the connection between the lost waters of the Danube and the increase of the spring at Aache, the experiment was tried of throwing down the clefts of the Jura several hundredweight of cooking salt, and drawing up samples every hour from the spring at Aache. This experiment had been preceded by one made with strong-smelling oil, which seemed to show that the connection was extremely probable. The second experiment with the salt led to the following conclusions :—

1. There is a direct communication between the Aache and the Danube.

2. When the Danube is at its lowest, between Immerdingen and Mohrungen, half of the water is seen forming the spring at Aache. The other half of the spring water is derived, not from the Danube, but from other subterranean sources.

3. The communication takes place through a perforated stratum of limestone in the White Jura, of about 1,050 feet wide.

4. As this perforated stratum is cross-vaulted, the fissures as a rule open downward, and sink as far as the clayey and marly substratum of the limestone ; and after a subterranean course of about 36,075 feet they ascend again, on the principle of connecting pipes, upward to the spring at Aache.

5. Ten tons of salt thrown into the Danube came to the surface again, or nearly all

of it, at Aache. The period of time during which the salt could be traced in the water was seventy-one hours: it was first perceived about twenty hours after it had been thrown in the Danube, was strongest after sixty hours, and ended about ninety hours afterwards.

6. The experiments made by colouring the water, or mixing it with oil, took effect in about sixty hours; that is, at the time when the salt was at its strongest; and they could only be traced at their maximum effects.

7. The neighbourhood of the Danube is less fitted for works wholly dependent on water power than the country round the Aache. For, not to speak of the frequent rise and fall of the Danube from null to high water, oscillations which only take place on the Aache within very narrow limits, it must be assumed from a geographical point of view, that the fissures in the bed of the Danube will increase and widen in course of time by the solvent force of the water, so that the water will sink more and more, and benefit Aache in proportion.

3. Springs rising in lakes situated on high levels. It is only in rare cases that the connection between springs and lakes upon higher levels can be directly established; but it is clear that when such a lake is found with no outlet, and containing more water than it can dispose of by evaporation, there must either be an alteration of the surface level, or subterranean discharges which break forth as springs. The lake Glacé d'Or, in the Pyrenees, 31½ miles above Bagnères de Luchon, is one of these lakes. It is situated 8,610 feet above the level of the sea, is about 600 feet long and 360 broad, and is surrounded by high mountains of granite and gneiss, whose steep sides are covered with glaciers and ice down to the edge of the lake. The lake is always frozen. Charpentier, in September, 1810, and October, 1811, found the surface frozen hard. He noticed some clefts filled with ice extending all through the mountains, and forming a subterranean channel which opens below the commune of Beque, and appears as a fine spring.

4. Springs arising from glaciers and melting snow. We shall have to speak of these more at length.

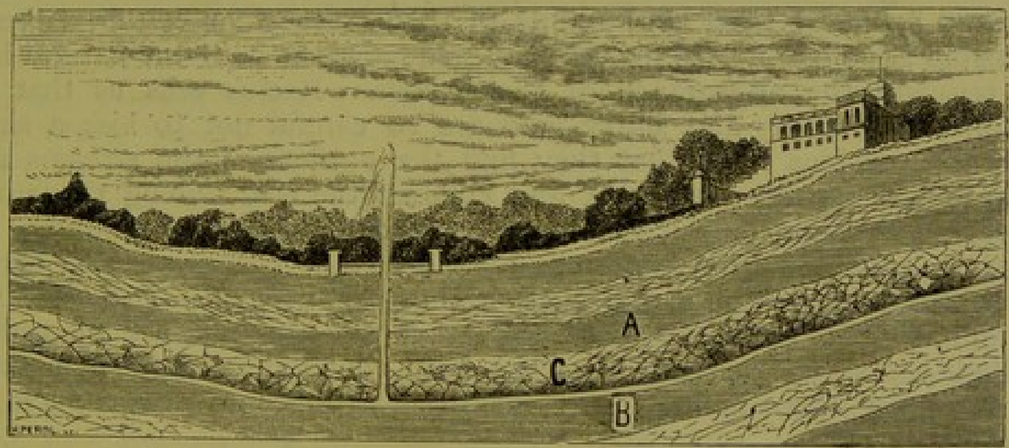
5. Mountain springs.

6. Deep-seated or mineral springs belong to the most interesting class of springs, whether considered as regards their method of appearing, their mineral properties, or their temperature. Where they are bored artificially, they are called artesian wells, and it is of these that we shall speak in our next chapter.

Artesian Wells.

The interior of the earth, at least in its upper parts, consists of pervious and impervious strata. It is very seldom that these strata are found lying horizontally, the one over the other; as a rule, they exist at every kind of incline. In the accompanying sketch we will assume A and E to represent impervious or non-porous strata of clay enclosed in a porous sandy stratum, C. When the strata are curved, as here represented, and reach the surface on the high ground adjoining, the water of the rainfall sinks through the sandy stratum, and remains checked and detained by the substratum of clay under the pressure of the column of water above it. If, therefore, the upper stratum of clay is pierced, the water must rise violently upward under pressure from below, and create an artesian well. It is of course the hydrostatic pressure of the column of water which occasions the upward rise in the artesian well; and anything which increases that pressure will also forward the upspringing of the water. This is confirmed by experience. Sometimes the force of the compressed masses of water is so great, that they burst through the ground unaided, and the well is formed. This was the case in Ripon in the year 1821, when the earth opened with a loud rumbling noise, and a column of water shot up, and hollowed out for itself a pit several feet in circumference and fifty-eight feet deep. Similar occurrences are recorded as having taken place in the sandy soil of Mark Brandenburg. Thus in the year 1756, not far from Ziesar, at the foot of the sandy ridge on the left bank of the Bukau, a spring burst out with a loud report in the night, and has continued to flow with undiminished force ever since; indeed, it contains more water than any of the neighbouring springs. By the continuous washings from the hills a deep ravine has been made in the loose soil, and the spring has considerably retreated; while behind the pit a channel more than five hundred paces in length has been formed, thus plainly showing that the source of the spring must be sought for far within the interior of the sandy ridge.

This kind of well bears its name from the French county of Artois, where great attention was bestowed on their formation in former times. Sunken wells, however, were known to the ancients, for Olympiodor records that in Egypt wells were sunk to a depth of five hundred ells, and the water used for the irrigation of the fields. Some of these very wells have been restored in modern times. Artesian wells are very common in China; in



SECTION DRAWING OF ARTESIAN WELL. A B, CLAY STRATA. C, SAND STRATA.

the neighbourhood of Uchungkiar there are no less than ten thousand. Their construction is of the most primitive kind. A steel bore is used, fastened to a rope, and drawn up and down with a slight circular movement. Several pits bored in this simple way have a depth of more than two thousand feet.

The oldest artesian well in Europe is found in the Carthusian convent at Lillers, and is said to have been sunk in the year 1126. The sinking of artesian wells in North Africa has been practised as long as history exists. A traveller journeying through the Berber's country in 1727 describes the way in which the inhabitants living in the villages situated farthest from the boundaries of Sahara used to procure water. Sinkings were made through the sandy soil till a substratum of gypsum was reached, and when that was pierced, the water shot up with such violence that the workmen were sometimes overtaken by it and suffocated before they could be drawn up to the surface.

Modern travellers have more to tell of these wells. Berbruegger has travelled through all the northern district of Sahara, and observed the methods in use for sinking wells. The mouth of the well is about ten feet wide on the surface, and is narrowed downwards like a funnel till it is only three feet wide. The sides are planked with palm wood. The last crust is broken through with a triangular hoe, and many declare that the rush of the water is heard through a stratum from one to two feet thick. The water shoots up with the speed of lightning, tearing the sandy soil along with it. The workmen cling to the ropes with all speed, and are drawn to the surface as quickly as possible, but they frequently reach it stunned and blinded with water and sand. The well is then cleaned out by divers, who bring up baskets full of the sand deposited at the bottom. A well sunk in this way may last, or *live*, as the natives say, for one hundred years. As the success of the date crop, and indeed the very existence of the country, depend on the condition of the wells, the French have done the people of the country great service by sinking more than fifty artesian wells.

Different kinds of live fish are frequently found in the waters of these wells, and also in the natural funnel-shaped openings found at several points of the Oued-Rhir. These openings, or *Bahr*, as they are called, are from thirty to forty feet wide. They supply a great quantity of water, and it is very probable that in past ages they suggested to the thirsty inhabitants the idea of sinking artificial wells. We not only find that men have been able to take and profit by such kindly hints of nature, but that certain tribes of Afghanistan have manifested a wonderful acquaintance with the natural laws which regulate the appearance of these wells. Reclus tells us that the inhabitants of that dry and sultry land are so careful not to lose a single drop of the precious fluid, that they find the outflow of the streams sent down to them from the mountains, and conduct the water along the valleys in underground channels which follow the general slope of the ground. The water thus protected from the sun's rays does not evaporate, and arrives almost without diminution at the base of the rock, where it is received into wells, and used to water the fields. Most of the channels are pierced all along their course by several little wells, from which the people living near draw water for their fields. Some of these subterranean acqueducts are 180,290 feet long.

In a book published at the beginning of the present century, and treating of natural curiosities, we are told the following particulars of well-sinking in the Duchy of Modena. In this very flat country the wells have to be sunk to a depth of at least 120 feet to reach the water. It is a curious fact that a great lake flows 120 feet deep below the duchy, and supplies all the wells with water. This fact is proved by the presence of a non-porous stratum of stone, several feet thick, which is found in every place where a sinking has been made, and which has to be worked through, because the water flows beneath it. Experience has taught the workmen to be very cautious when the last stratum is nearly broken through, for the water rushes in to the height of seven or eight feet at the first moment, and it is often a difficult matter to escape in safety.

This same risk is also incurred in other sinkings; for on the 15th of September, 1763, when the pit near the Sool at Durrenberg had been dug to a depth of 791 feet, and there remained still a stratum of gypsum twenty-three inches thick between the workmen and the river, the latter suddenly burst through, and in little more than two hours filled the whole pit, which was six yards in circumference, and overflowed the top. One of the workmen was overtaken by the river, and carried up with it 252 feet to the surface, which, however, he reached in safety. The idea that there is an unbroken sheet of water below the Duchy of Modena is, of course, utterly unscientific, but still it is not necessary to imagine the water which supplies the artesian wells as flowing always in very narrow channels. It is sometimes collected in large reservoirs, and sometimes in little rivers. There is an artesian well at Elbœuf which occasionally throws out eels. In the department of Haute Saone there are several natural funnel-shaped depressions, called *Frais Puits.* If heavy rain falls in summer and in autumn for two or three days together, the water rushes out of the opening of these frais puits like a perfect torrent, and overflows the country round. The inundations only last for a few hours, and often leave pike behind them in the fields and meadows over which they have passed.

Arago relates an interesting story of an artesian well in the treatise which he has written upon the subject. When the vertical pipe of the fountain in the market place before the Cathedral of Tours was shortened by four and a half yards, he tells us, the water issuing from it increased, as might be expected, in a considerable degree, that is, to nearly one-third of its former quantity; and the stream, which was generally clear, became turbid as its rapidity was so suddenly increased. For several hours it brought up from a depth of 350 feet fragments of plants, among which were branches of bramble several inches long, blackened by long immersion in the water; white roots and stems of marsh plants; several kinds of seed, in such a good state of preservation that it was impossible to think that they had been long under water (among the seeds were found seed of a herb which grows in marsh lands); and lastly, a few fresh-water shells. All these fragments resembled those found on the margin of a brook or river after an inundation.

We shall have to speak again of these subterranean rivers, and the cavities through which they flow; here we shall only treat of them as they appear flowing in artesian wells. In some cases the columns of water which exert the hydrostatic pressure, by means of which the water rises, are found at a great distance from the opening. The spring at Loiret, which may be considered as a natural artesian well, gives us an example of this. Its water supply is connected with that of the Loire, and when from any special cause the river suddenly rises, there is a corresponding rise in the water of the spring. And it is certain that the fresh-water springs in the sea are and can be nothing but natural artesian wells. The cogency of this conclusion is by no means diminished by the fact of the nearest coasts being 120 or 130 miles away.

The ebb and flow of the tide exert a singular influence on certain artesian wells. Thus a well sunk at Fulham, near the Thames, gives out sixty gallons of water at low tide, and eighty gallons at high tide; and a well sunk within the fortress of Lille in the year 1840 gives out as its maximum fourteen, and as its minimum seven and a quarter gallons a minute. The greatest height to which the water reaches is two and a half yards, and its smallest two and one-eighth. The greatest differences in the height and quantity of the water correspond to the syzigies or new and full moon, and the smallest to the first and last quarters. There are also said to be "tidal" wells on the west coast of Iceland, or at least wells which rise and fall with the tide of the sea. According to Schomburgk, there are artesian wells in British Guiana, whose waters rise at the spring tides to a height of one yard.

Arago gives the following explanation of the manner in which wells are affected by the ebb and flow of the tide. He says, "If an opening be made in the side of any vessel filled with liquid, the dimensions of the opening being very small in proportion to those of the vessel, the outflow through this opening will not perceptibly affect the pressure exerted by the water before the opening was made. And if three, four, or ten openings be made, always supposing that they are sufficiently minute, the pressure on every point of the vessel a little removed from the openings will be left unaffected, remaining the same as it was in a condition of perfect equilibrium when the liquid was at rest. But if we imagine one or more of the openings to be made larger, all the conditions are altered; the pressure on every point will be dependent on the dimensions given to the opening, and if the size of one of them is lessened, the speed with which the liquid flows out of the others will increase.

"It is easy to apply these uncontested laws of hydro-dynamics to the phenomenon of the artesian well and its connection with the tides. Suppose the subterranean river from which the well receives its water empties itself partly into the sea, or into a tidal river, through an opening which is large in comparison to its own dimensions. According to what we have just said, as soon as this opening was diminished, the pressure exerted on every point of the natural or artificial channels which the river fills with its water would increase, the outflow would become quicker, or if the conduit were vertical, the water would rise. It is evident then that the rising of the tide in consequence of an increase of the outward pressure upon the opening through which the subterranean river pours itself, must have the effect of diminishing the volume of water which otherwise could issue from it in the same period of time. The effect therefore is exactly the same as that which would be produced by diminishing the size of the opening, and the result must consequently be the same; so that the ebb and flow of the sea's tide will produce a corresponding ebb and flow in the artesian well."

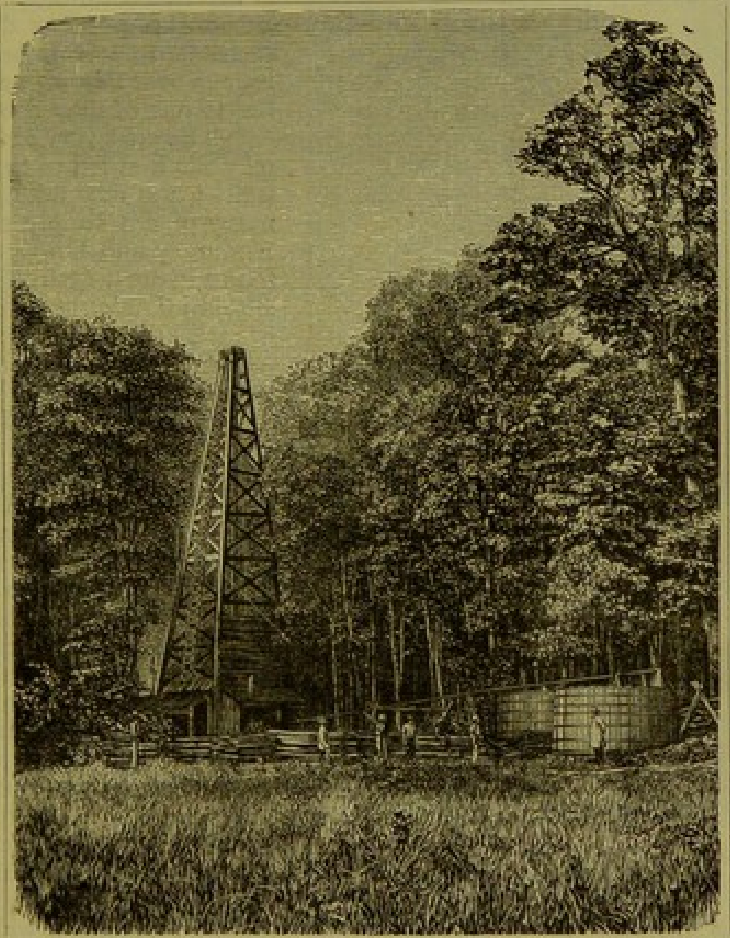
There is great diversity both in the depth and the volume of artesian wells. The famous fountain at Grenelle is six hundred yards deep, and descends below the bottom of the sea by the neighbouring French coast. It throws up a jet of water thirty yards high. The sinking began on the 30th December, 1833, and after many mishaps during the process, reached the water on the 26th February, 1841. The workmen had then come to a stratum of quartz and sand, when the water shot up with great force, bringing with it sand, sharks' teeth, and several gryphæa. The works, which cost £14,480, were not completed till the 30th of November, 1842, and since that time there has been a plentiful supply of clear water. The well brings to the surface every minute 484 gallons of water, or 770,000 gallons a day. Certain curious anomalies were noticed concerning the water supplied. For instance, on the 16th of November, 1483, it became troubled, and in the night between the 23rd and 24th of December it cast up clayey substances. In the following January the water decreased by one half, and in February it became clear again. The diminution of water took place at the same time that a shock of earthquake was perceived at St. Malo. The shaft at Rehme, in Westphalia, is 798 yards deep, and supplies 320 gallons of water a minute. The artesian well completed at Passy in September, 1861, is 615 yards deep, and supplies 1,210 gallons a minute.

The deepest artesian well which has been sunk as yet is at St. Louis. It was already seventy-two feet deep when the sinking was begun. A large pipe of cast iron, reaching to the bottom, was lowered down, and inside this pipe was another made of wood, and measuring four and a half feet in diameter. The sinking was begun on the 31st of March, 1866, and continued day and night, Sundays excepted, till August, 1869. The well was then 4,934 feet deep. The works passed through sixty-three feet of clay, six of coal, 360 slate, 2,860 of limestone, and 710 of sandstone. At the beginning of the work the water was within forty feet of the surface; at the depth of 134 feet they came to a subterranean passage nearly a foot wide, through which the water fell to a depth of 134 feet. At 1,285 feet below the surface the water had a salt taste, and at 2,245 feet deep it tasted of sulphur.

In sinking these deep artesian wells, the workmen are sometimes met by a reservoir of gas. This seems to have been especially the case in the salt-water wells in China, and sometimes gave rise to terrific explosions, while at other times the heating power of the gas was used to keep the salt pans at boiling point; indeed, the Abbé Imbert tells us that the gas was conducted through bamboo canes, and used to light the streets and houses at night. In sinking an artesian well at Lormeilles, there was a sudden escape of hydrogen gas up the shaft, so that the works had to be suspended until it was exhausted, which happened very soon.

There are some very important gaseous springs in Pennsylvania. If a shaft is sunk to any considerable depth, the gas escapes in great quantities. At Delameter, when the mine had descended to the third sandy stratum, a well of petroleum was struck, which, by the time the next stratum of sand was reached, yielded 352 gallons of gas of such tension that a sounding lead weighing fifteen hundredweight could easily be lifted by the hand. Each of these wells was half a foot in diameter.

The well at Delameter furnishes double the quantity of gas yielded by other wells of the neighbourhood, and from its supplies the whole town and district round is lighted. It is situated in a valley entirely shut in by high mountains. Several pipes are laid down to carry off the gas, one of which carries it direct to the cylinder of a large engine, which it works with great speed. When the gas issuing from the cylinder is set on fire, it throws out a mass of flames. Another pipe supplies a flame capable of reducing as much ore as would supply half the furnaces at Pittsburg. A third, three inches in diameter, sends up a column of fire forty

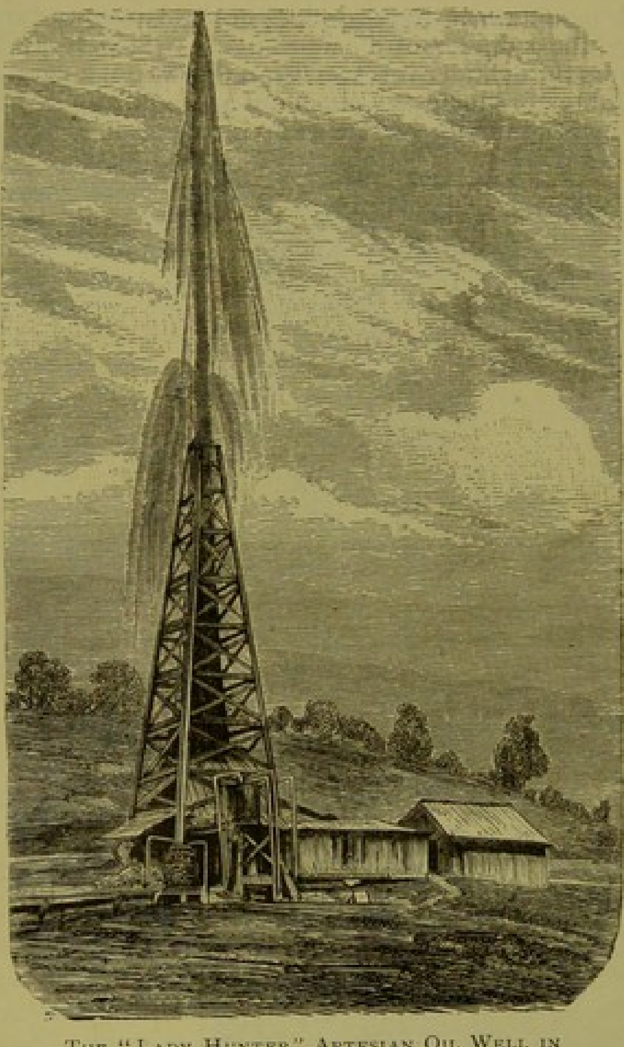


GAS WELL IN PENNSYLVANIA.

feet high. The earth round the spot is burnt up within a circle of forty feet, but outside that circle the vegetation is as luxuriant as that of the tropics. On a calm night the roaring of the flames can be heard fifteen miles away. The flame shoots up high in the air, and presents the appearance of a burning steeple. In winter time, when the surrounding country is white with snow, the land round the oil well is covered with rich vegetation. The composition and pressure of the gas are carefully studied. It consists of carburetted hydrogen, carbonic oxide, and carbonic acid. The pressure in the pipe, measuring $5\frac{5}{8}$ inches in diameter, is a hundred pounds to the square inch. In a smaller well it is two hundred pounds, and at the end of a pipe two inches in diameter, and which is laid down as far as Freeport, a town fifteen miles away, the pressure is still 125 pounds. The ascending power of gas amounts in round numbers to 1,700 feet a second. This gives a volume of 300 cubic feet a second. As to the duration of the well, it is said to have flowed now for fifteen years without showing any signs of a diminution of quantity.

Another well at Fairview has supplied a hundred engines for five years, and yields as freely as on the day it was opened. The application and use of these immense stores of heat and light is as yet in its infancy. At Pittsburg, two ironworks are entirely supplied by the gas from a well fifteen miles away. This well is 1,200 feet deep, and half a foot wide. The pipe which carries it to Pittsburg is six inches wide. The gas is principally used for puddling.

The oil wells of America are true artesian wells. One of the finest is the so-called Lady Hunter's Well, opened on the 9th of October, 1874, and which furnished in eighteen months 145,000 casks of petroleum. And the artesian oil wells at Pithole yielded eight hundred barrels of petroleum a day. This well was opened in January, 1864, and was exhausted in a year. In the oil district of Gallicia the yield is reached by sinking shafts. The most important is the Bobska mine. Thunderstorms are beset with peculiar dangers in these oil districts, and it is seldom that a storm breaks over Pennsylvania without setting fire to one of the oil works.

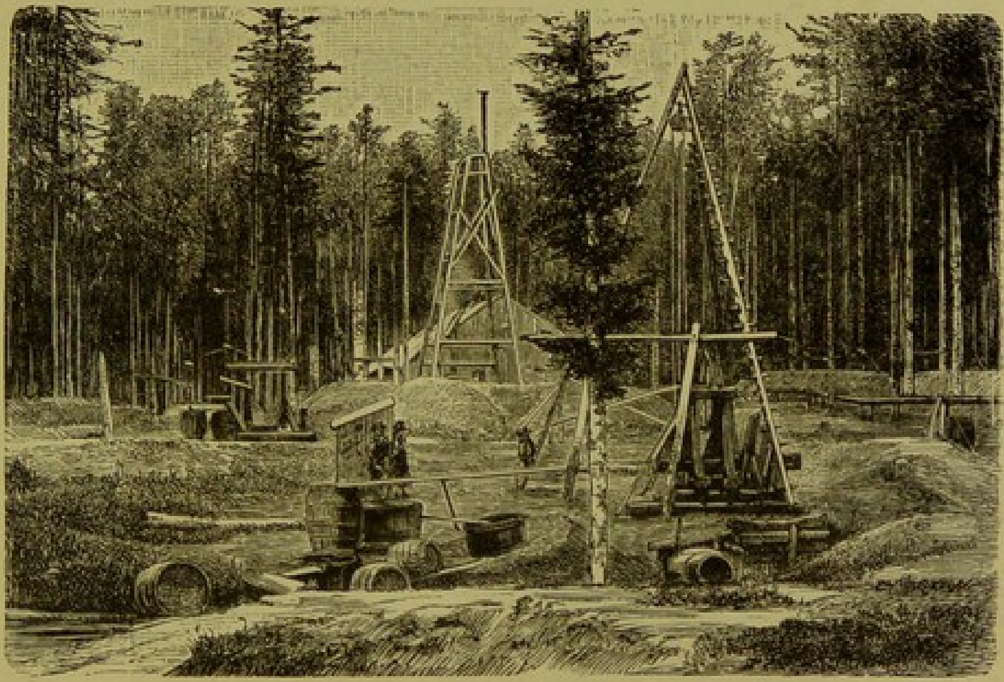


The "Lady Hunter" Artesian Oil Well in Petrolia City.

The discovery of the North American oil wells first led to the sinking of gaseous wells; and now works are carried on in many places simply to procure gas. In Kentucky and Upper Cumberland, gas is found in such quantities under the lower silurian lime strata, that hundreds of tons of rock and earth are from time to time hurled into the air by the explosion of these *gas-volcanoes*. Gas is found in almost every part of the oil district of Ohio.

Two wells in Knox County deserve special attention. They were sunk in 1866, through the same geological formation as that which furnishes the oil in Oil Creek. At the depth of six hundred feet a stratum was reached, from which such a volume of gas rushed out, that the sinking apparatus was blown up, and a column of water rose to a height of more than a hundred feet above the pit's mouth. One of those wells was provided with pipes which drew off the water, and allowed the gas to rush through a pipe two and a half inches wide. The roar of the gas through this pipe is heard at a great distance from the place; and when it is lighted, it throws out a flame fifteen feet long and eight feet wide. The other well, which has no water pipes laid down, casts up water at intervals of a minute, and so becomes an intermittent spring 120 feet in height.

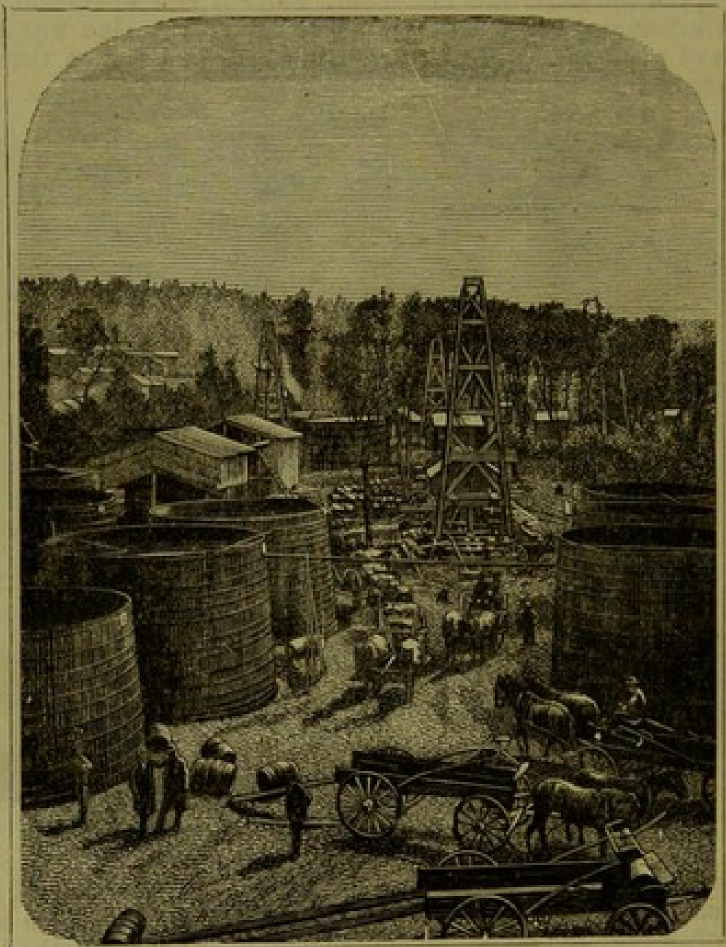
A curious escape of gas occurred during the knocking in of a pump staff for a pump at Delft, in Holland, in the year 1870. On the 3rd of August, when the point of the staff had attained a depth of fifty-seven feet, a strong rush of gas was heard. A stream of water followed, rising above the top of the pipe, and flowing with such force as to displace the machinery at the bottom. When the latter was removed, a column of foaming water rose to a height of forty-five feet above the surface, and continued without intermission for fourteen hours. The rise then became intermittent, occurring at intervals of nine minutes. After this pause of comparative quiet the water poured forth with greater violence than ever, rising above the top of the pipe, and keeping up a large jet twenty-six feet high. After a while the water sank, and nothing but foam and froth rose above the pipe, and lasted about two or three minutes. The upper end of the pipe was about six feet above the ground. The gas sent out was inflammable, and burnt with a large but not very intense flame, which cast a weird and singular light around the scene toward the end of the time when the gas and water rose together. When the stream was at its strongest, the force with which it rose did not admit of any continuous flame being obtained. The intermittent rise of gas and water lasted from the 4th to the 21st of August, and the periods of rest increased, gradually and very slowly at first, becoming more marked after the 14th of August. On the 17th of August the resting time occupied one hour, on the 18th, four hours, on the 20th and 21st, about six hours. On the 21st of August the last outflow of water was observed. Nothing was seen afterwards but risings of gas, which were only intermittent, small gaseous bubbles forming on the surface of the water, with one large bubble every ten minutes. The increased pressure occurring every ten minutes could be clearly felt by any one who laid his hand over the top of the pipe. In this way it was possible to create an eruption of gas and water at pleasure. During the periods of resting time the gas could be kept steadily burning, the light being dim and faint, but gaining strength and brightness whenever a large bubble rose to the surface. The well continued in this condition until the 19th of September. After that date, the pipe, being sunk to a depth of eighty-one feet, brought up some drinkable water, but mixed with sand. An attempt was made to pump out large quantities of sand and water, but the water was not good. After a rest of several hours it was found that quantities of inflammable gas had again collected; the pipe was then driven farther down, to a depth of one hundred feet through the sand, and it was then possible to obtain good drinking water.



PETROLEUM WELL IN GALLICIA.

At the beginning of the eruption only the proprietors, workpeople, and villagers were present, and no one was able to take any satisfactory observations from a scientific point of view. But the brown-coloured stains left on the adjoining houses by the jet of water showed that the stream contained a large quantity of iron, and probably a considerable admixture of carbonic acid. Before the second eruption took place, Professor Bakhuizen had reached the scene of the occurrence. He noticed that the periods of rest and disturbance were observed with great regularity; also that the water remained motionless within the pipe for a few seconds before each outburst. The gas was collected and analysed from time to time. It was found to contain carbonic acid, marsh-gas, and traces of atmospheric air. There were no signs of carburetted hydrogen or methyllated spirit. A rather thick stratum of loam extends below the wells and the turf, at a depth of about ten feet. Below this, at a depth of eighty-one to one hundred feet, pure sand was met with, and sinkings made in other places showed that the sand reached a depth of one hundred and sixty-five feet. Simple as these geological observations are, they have great weight in explaining such occurrences as the one just described. The three periods must be considered separately. In the first period, large quantities of gas and water confined under great pressure were suddenly set free by the opening made in the loam. The gas, composed of organic remains, was now able to rise up the pipe, driving a strong column of water before it. When, during the second period, the pressure of gas decreased so much as to send out no constant jet of water, it collected again during the periods of repose below the layers of loam, and if its power was sufficient to throw up a jet of water through the pipe, an eruption occurred. At the lower end of the pipe there were constant alternations of small upward streams of gas and water, but the gas was not found in sufficient quantities to keep up a continuous current of water. The third period began when the dynamic equilibrium between the gas and water was restored. It is obvious that when the pressure was increased by closing the top of the pipe, the gas would increase in force, and the former occurrence would be repeated. It has not been ascertained where the gas came from. There is no doubt that it was generated under ground by the slow and long-continued decomposition of organic, chiefly vegetable, remains; but no practical information as to the source of any gas spring in the neighbourhood was obtained.

It is a universal and important law that the temperature of the water in

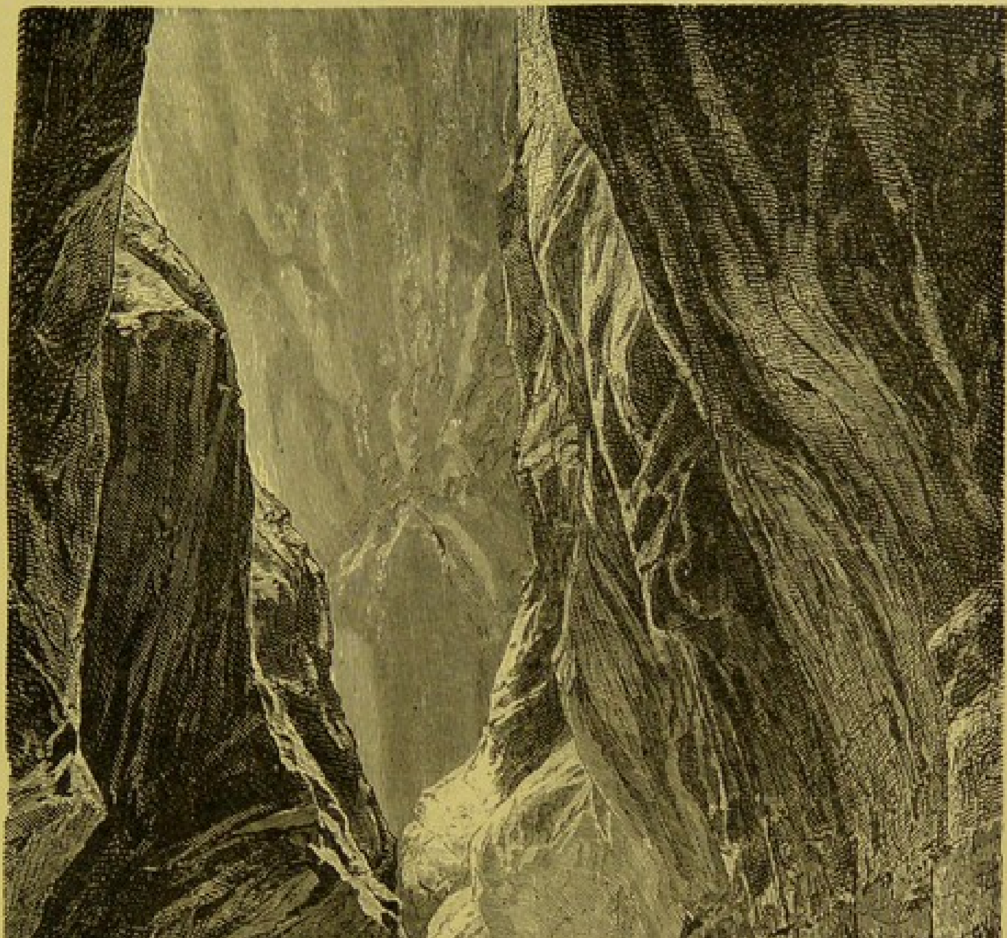


Oil Well at Pithole.

artesian wells rises in proportion to its depth. It is found upon an average that the increase of warmth amounts to 1° C. for every ninety-seven feet. We shall recur to the reasons and significance of this rise of temperature in another chapter.

Periodical and Intermittent Springs.

From what has been already said of the origin of springs, the probability of a variation in the quantity of water yielded by each spring must have already suggested itself. Experience fully confirms the idea, and it is easily shown that our springs, as far as their amount of water is concerned, are closely connected with the meteoric rainfall. In rainy years the flow is

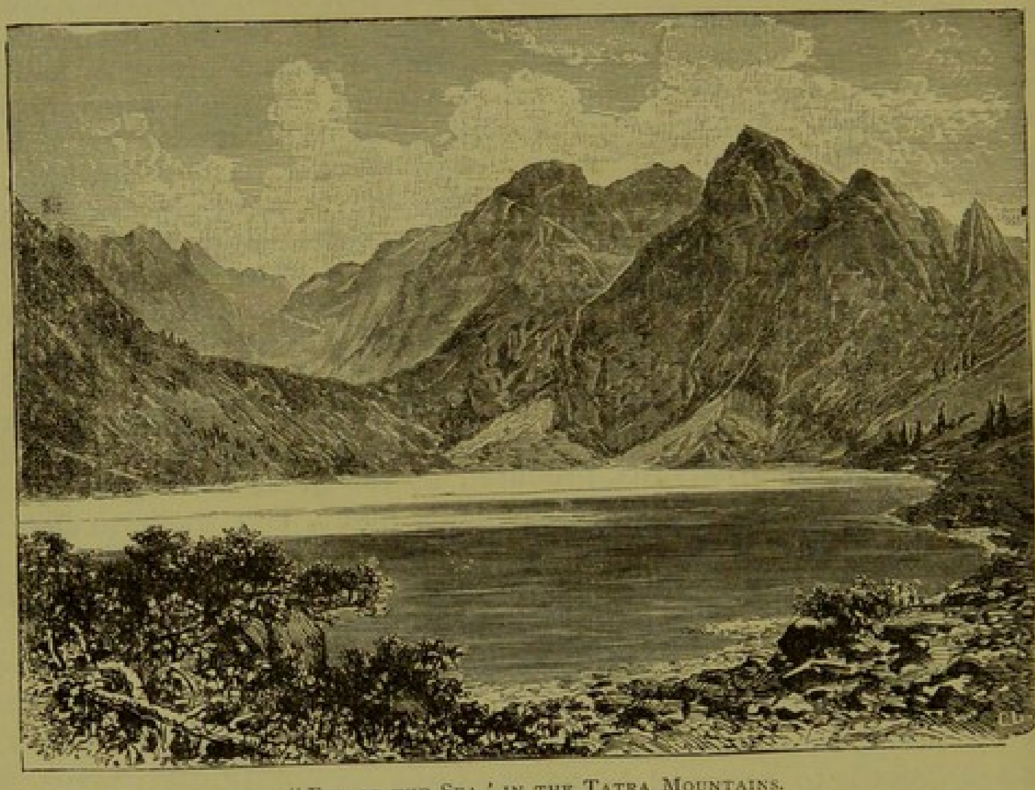


THE TAMINA GORGE, NEAR PFÄFERS, SWITZERLAND

abundant, and in years of drought scanty or none at all. The nearer the bottom of the well is to the earth's surface, and the smaller the area which supplies it by tributary channels, the more dependent it must be upon the amount of rain which falls upon the area. On the other hand, if a well is very deep, and its tributary area large, its yield appears to a great degree independent of the distribution and amount of rain on the surface. Not that a well can ever be entirely unaffected by long-continued drought; for even those springs which "have never been known to fail within the memory of the oldest people living near them," occasionally astonish those who have never doubted their continuance by running dry. And this failure is repeated at much shorter intervals by ordinary wells, which flow during heavy rains, and disappear altogether in times of drought. In rocky districts, where there are many crevices and fissures in the stone, cavities are often found which appear as wells only when the underground reservoirs are very high; and if the reservoir lies below the base of the cavities, the wells must inevitably dry up in rainless seasons. Many instances are recorded which show how considerably the level of the subterranean waters may vary in the course of the year. A sunken well situated in the chalky marl of the mountain range 146 feet above Lippspringe, was considered to be inexhaustible even in the driest summers. It was 122 feet deep, and in rainy seasons the water was sixty or seventy feet below the mouth, which is about the same height as the surface of the Becke, at Neuenbecken. In rainy seasons, water runs down from the Becke, showing that the subterranean reservoir must reach the bed of the stream; and as the bed lies sixty-eight feet below the well above-mentioned, the depth of the water below the surface is established.

Among the more famous periodical springs are the *Famine Springs*, or *fonts famineuses*, also called *crie la faim*, because when they are full the peasants anticipate bad harvests, produced by too great moisture. Another well near Steigeregg is called by the same name, and tradition says that when the spring is dry there is a good year, and a bad one when it flows. And the so-called Corn-famine Spring at Steinmark, on the borders of Carinthia, has the same evil reputation, so that when it ran dry in 1854, the pastor of the village exclaimed, "Lift up your hearts; we shall have a good harvest."

In Graubünden there are two springs which flow from April to September, and are dry during the remainder of the year. They rise in the rocks, and are only twenty-five paces distant one from the other; and a still more curious instance is to be found in the Häslithal, where there is a well which generally flows only from May to September, and even then not constantly, but for a few hours in the afternoon and evening. Sometimes, however, it does not begin till evening, and then flows all night long. In the mountains at Kaluger is a spring which flows late in the autumn, ceases on the 7th of November, and flows again on the 7th of March. The waters at Pfäfers are another instance; they flow every year in May, and disappear in September; not always keeping strictly to these dates, but varying sometimes by a month. The Liebfrauen spring, near the Loetsch Glacier, does not begin till June, and ceases in September. In the higher portion of the Tatra range of the West Carpathian Mountains there are numberless little ponds or pools, called Eyes of the Sea, and which are for the most part nothing but wells. The surface of the water shows great variations of level, being in spring and summer four, five, or even twelve feet higher than in autumn and winter. The connection between this variation and the melting of the surrounding snow and the rainfall is too evident to be dwelt upon, and is supported by the examination of the overflowing springs, or *estavelles*, in Languedoc. These springs have a common system of connection at their root, or base, and several mouths, many of which are generally dry. Whenever the underground tributaries are unusually high, as is the case after much rain or a heavy fall of snow, the reserve wells begin to fill. The famous estavelles of Prunkrut are four large wells which rise in the town of that name, and are fed by a vein of water flowing from the mountains lying to the south-west. This vein of water is easily traced to a well situated at the base of a hill some two and a half miles distant from the town. There is generally water to be seen low down in the well; but when the snow suddenly melts, the water rises to the mouth with great force, and flows out toward Prunkrut. A few thousand yards to the east of Vesoul is another similar estavelle, which generally pours its overplus of water into a large well at Champdamoy. When, however, the subterranean cavities cannot contain the amount of water collected the

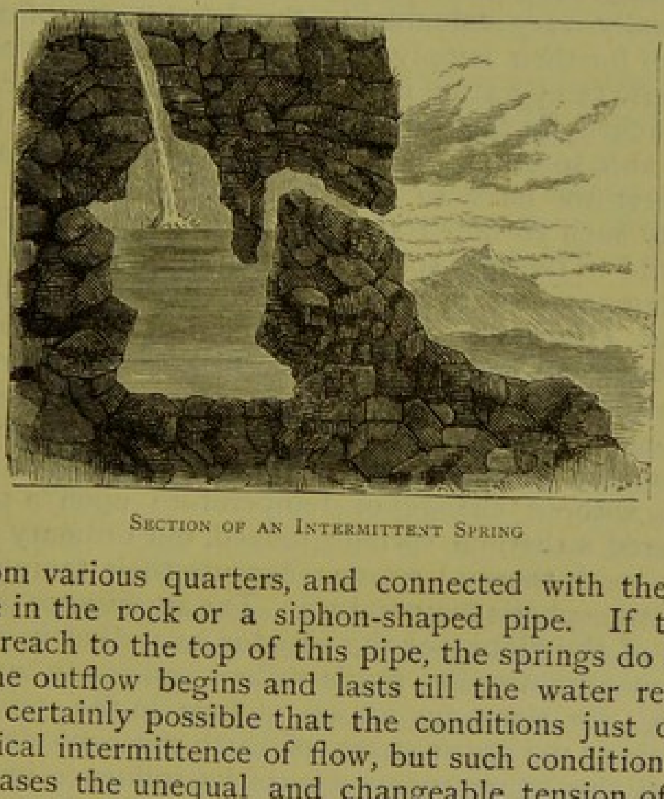


"Eye of the Sea" in the Tatra Mountains.

estavelle flows into the *frais-puits* a short distance beyond Champdamoy. Sometimes a perfect river overflows from these mouths, inundating the fields round Vesoul for many square miles in circumference, and causing the little valley streams, and even the Saone itself, to overflow their banks. This *frais-puits*, with another spring near it, has been known to yield the enormous amount of 130 cubic yards a second, or more than double the quantity of water carried by the Seine at low water under the bridges of Paris.

Sometimes one or other of the estavelles overflow without any rain having previously fallen. On the 13th of May, 1854, the two upper estavelles of the Chalet broke out about six o'clock in the afternoon, after a storm which had been raging on the mountains of Larps. At the same moment an entirely new spring broke forth near the well at Lavak, and yielded so much water that the Chalet suddenly rose more than a yard in height. Several theories have been put forward to explain this phenomenon, all of which have more or less plausibility, but too little is known as yet of the divisions of the subterranean watercourses to spend any time over mere speculations.

Many springs have a daily cessation of their flow, and among them the famous Bullerborn, near Paderborn, has attracted much attention. It is said that until the beginning of the present century the Bullerborn only flowed six hours a day, and yielded sufficient water to turn three mills. At the present time it is nothing but an ordinary and rather insignificant spring. In the neighbourhood of Eichenberg, in Hesse, is a spring which ceases to flow every two hours, and keeps its time with great regularity. A large spring in the Lower Engadine is said to flow only in the morning, at noon, and in the evening. How far the accuracy of this and similar statements would bear severely testing is very doubtful; but judging from similar reports of other springs which have been strictly noticed, none of such reports must be taken to the letter. The probability is that there is an intermittence of flow occurring at longer or shorter intervals, and which has been explained in the following manner. Suppose one or more underground cavities fed by tribu-



SECTION OF AN INTERMITTENT SPRING

taries coming from various quarters, and connected with the surface of the earth by a fissure in the rock or a siphon-shaped pipe. If the water in the cavities does not reach to the top of this pipe, the springs do not flow; but if the water rises, the outflow begins and lasts till the water regains its former level. Now it is certainly possible that the conditions just described would occasion a periodical intermittence of flow, but such conditions are rarely met with. In many cases the unequal and changeable tension of the air causes the intermittence; it is clear that the accumulation of gas has much to do with the phenomena. This is shown by a periodical well in Jura, where there is a ceaseless flow of water from below into the bottom part of the pit, but the upper part only flows at intervals of about six minutes. The half-hourly rise and fall of the saline springs at Kissingen is occasioned by the development of carbonic acid gas; and a similar periodic yield of water from a pit at Pranal is owing to the same cause.

THE TEMPERATURE OF SPRINGS.

The average temperature of the springs rising from the centre of the earth differs but slightly from that of the surrounding atmosphere. In equatorial lands the temperature is rather lower, and in other places rather higher than the average yearly warmth of the air. Springs flowing from the upper strata of the earth, that is, from those which are directly subjected to daily and yearly changes of heat and cold, are hotter in summer and colder in winter. The greater the depth from which the water comes, the slighter will be the difference between the highest and lowest temperature, the average warmth of the deep wells being greater than that of the shallower ones. Indeed, the law is everywhere established, that those waters which rise from the greatest depth are the warmest; this has been placed beyond all possibility of doubt by the temperatures taken during the sinking of artesian wells. Mountain springs created by the fall of meteoric waters, and flowing downward to the valley through porous strata, generally arrive at their resting place with a lower temperature than that of the air around, because the water is not perceptibly warmed by passing through the warmer strata. Springs in Teneriffe, flowing from heights the difference of level of which varies by more than 1,400 yards, bring down with them the cold of the upper regions, and retain it almost undiminished throughout their rapid subterranean course. These mountain springs are naturally very valuable to the inhabitants of the valleys, who depend upon them for their supply of drinking water. In places where the average atmospheric temperature is 68° Fahr., and even more, and where this temperature is reached by the ordinary wells and springs, it is of the highest importance to be able to obtain the cold waters of the mountain springs.

In this chapter we have to deal principally with the hot or thermal springs which play such an important part in the organism of our earth. The transition from cold to thermal springs is of course a gradual one, rising from springs with a temperature but little above freezing point to the Aguas Calientes of Las Trincheras in South America, which form a stream of almost boiling water. It is, however, by no means necessary to classify these springs by following their gradual rise in temperature too closely, or to make sub-divisions of cool and lukewarm springs; the more so as of course heat and cold are but relative terms. A cold valley spring, if it could be suddenly placed without change of temperature upon a mountain height, would be considered a thermal spring; indeed, our ordinary cold springs are, strictly speaking, weak thermal springs, because their temperature is a little in excess of the atmospheric temperature. The appearance of thermal springs in every quarter of the globe—at the equator, as well as in the polar circles, in lowlands and mountain peaks, fertile valleys and sandy wastes—is a fact of great significance; for since any excess of heat in the spring water beyond the heat of the air or the upper strata of earth must be derived from some other source, and this other source exerts its influence in all parts of the globe, it must be of universal extent. Such is indeed the case, for the source and fountain of the heat of all our thermal springs is to be found in the great central heat of the earth's core.

As far as we know, this central heat is invariable, and consequently the thermal springs maintain an unchangeableness of temperature which is in some cases really astonishing. Of course there are local influences which here and there affect the heat of certain springs; but while the inner central heat is communicated unchanged to the thermal springs, the heat produced by other causes is never constant, and the temperature of the wells affected by it varies with its changes.

If heated or molten masses rise from the centre of the earth above their level, or remain shut down close below it, the waters of the earth's crust which come into connection with them become heated, and may form a thermal spring; but in this case, as the heated mass gradually cools, the waters cool down with it, until they have reached the normal temperature of the place. If the heated masses are of any great extent, thousands of years may elapse before they cool down, and hot springs created by them may flow during this long period, but of course with a gradual decrease of temperature.

In former stages of our earth's history, when the great masses of our crystalline mountain ranges either rose above the surface or were the cause of great upheaval and depression of the earth's crust, these phenomena must have been of frequent occurrence. *Débris* found in many places at the present day indicate by their peculiar formation and construction that they have been thrown out by hot springs, and as they are often met with where either there are no springs or only cold ones, they are accepted as proofs of the existence of former hot springs.

Instances of a relatively rapid cooling down of hot springs are found near recently extinct volcanoes. Humboldt records of the temperature of the hot springs at Jurullo, when compared with those taken by Burkart twenty-four years later, show a variation of eighteen degrees. The temperature of the gas rising through the fissures of the pass of Quindin, near Moral, has cooled down, between the years 1801 and 1827, from 118° to 66° Fahr.; and if there were a spring heated by the gas at this place, the temperature of its waters would have decreased in an equal degree. And conversely, a corresponding increase of heat is sometimes found in hot springs rising near an active volcano. Thus the temperature of the thermal springs of Maria and Las Trincheras has risen several degrees in the space of twenty-three years. It is most probable that this local increase of temperature was occasioned by a sudden rise of lava beneath the spring.

The thermal springs near Naples, known as *La Pisciarella*, rising on the outer cone of the Solfatara, are subject to great variations of temperature, which occur in a marked degree within extremely short spaces of time. And the hot springs near the volcano of Tanna, in the Hebrides, varies by several degrees in the course of a single day. Such rapid changes of temperature in the spring water indicate that corresponding changes are taking place near the course of the stream which feeds the spring, in consequence of volcanic disturbances, or else, which is yet more probable, that watery vapours rising at more or less frequent intervals create a changing rise and fall of temperature in the spring water.

Intermittent Thermal Springs.

In certain volcanic districts, such as Iceland, Java, New Zealand, and near the upper Yellowstone in Missouri, among the Rocky Mountains of North America, are found hot springs, from which the water rises at intervals high into the air, with great violence, accompanied by thick clouds of steam and loud roaring noise. The best known of this kind of springs are those found in Iceland, among which the Great Geyser holds the first rank. Its name comes from an Icelandic word *gios-a*, to boil, or, as it has been rendered by some writers, bubbling or *tempestuous;* at any rate, it is now applied to the whole class of thermal springs. In Iceland itself the hot springs are called *Hverjar*, and the inhabitants distinguish between those whose water is always in a constant state of ebullition and those which are sometimes at rest, during which time their water is not so hot, and which only throw up boiling streams at intervals. The latter are the intermittent springs, of which we are about to speak. Springs which never reach boiling point, and whose waters are in a constant state of quiescence, are called by the Icelanders *laug*, or warm bath. *Namur* is the name which they give to mud and sulphur springs, in which a fine bluish grey mud is seen in a constant state of seething and bubbling activity; while *Reykir* is a term applied indifferently to any hot vapour spring. The area in which the Icelandic hot springs are situated is not of any great extent; it is situated to the south-west of Hecla, in a plain at the foot of the Bjarnafall, which adjoins a rocky chain of porous stone. The traveller is warned from afar of his approach to the geysers, by the light vapour clouds floating round him. The exterior of the Great Geyser presents the appearance of a low mound, about seventy-six and a half yards in diameter and eleven in height. It consists of horizontal layers of silicious *débris*, which have been thrown up by the water from time to time, and fallen into its present position. On the top of this mound is a flat basin, about eighteen and a half yards in diameter, in the midst of which a pipe, about four and a half yards in diameter, is sunk vertically in the earth, to a depth of twenty-seven yards. Through this pipe the hot water rises.

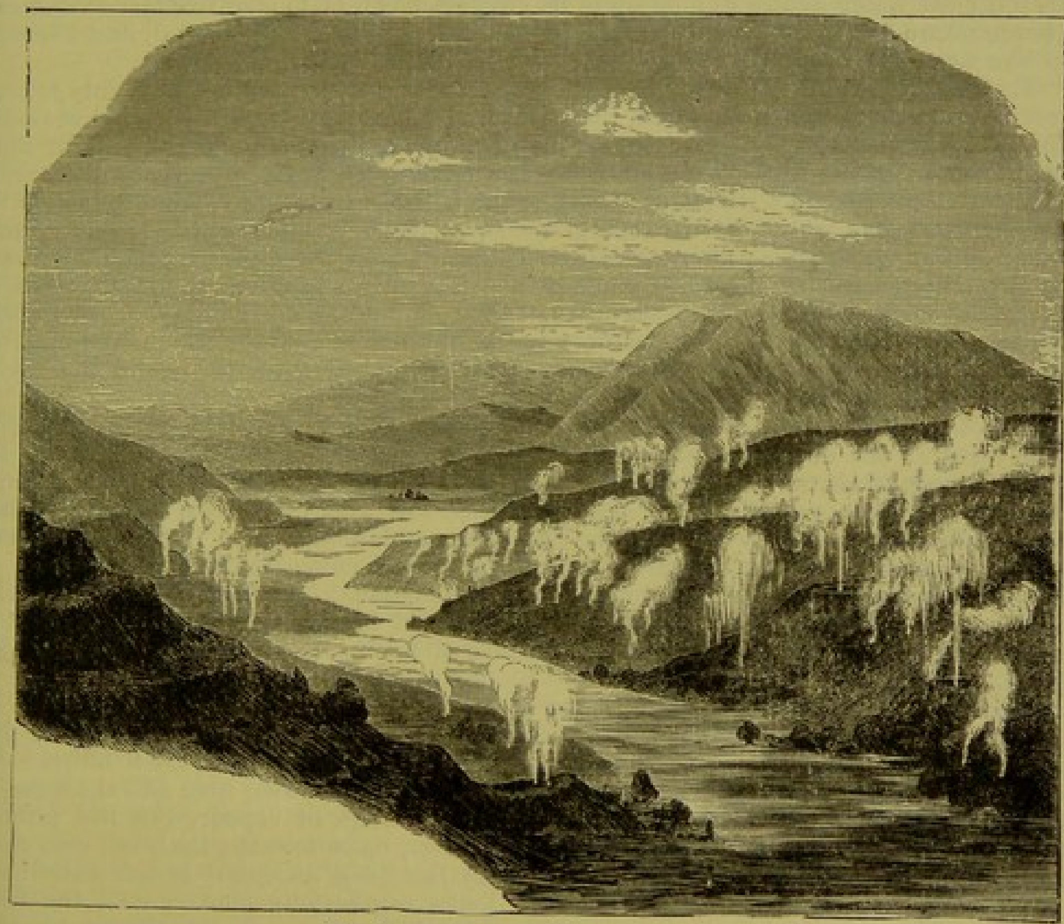
The temperature of the water in the basin stands at about 176° Fahr. At intervals of eighty or ninety minutes the subterranean thunder gives the warning signal for an eruption. The waters in the basin rise and swell, and masses of vapour drive them into the air, to a height of about five and a half or even nine yards. The first column is soon followed by a second and a third, still higher than the preceding. Short pauses occur between each eruption, until at last, frequently after the lapse of twenty-four or thirty hours, a magnificent spectacle is presented. Terrible rolls of thunder from below announce the crisis; the water of the basin swirls and rises, sending up immense gusts of steam and vapour, until suddenly, with the rapidity of a flash of lightning, a mighty shaft of water shoots like a rocket in one unbroken stream, veiled in clouds of steam, to an enormous height. From time to time small jets of water break off sideways, and fall over in arched curves; the close white masses of steam sometimes veiling, sometimes revealing the waters within. This grand sight occasionally lasts for ten minutes, when the great column sinks and disappears without a trace. While the boiling streams are still pouring down the flinty mound, the inner basin is left dry, and even in the centre pipe the water does not reach to within more than a few yards of the top, and its surface is as quiet as that of any ordinary well. The spectator may now advance in safety to the edge of the pipe, and carry out the observations, the hope of which has perhaps caused him to visit the spot. The Great Geyser, however, is by no means regular as to the periods of its grand outbreaks; sometimes, indeed, it is capricious enough to allow three days and more to elapse without gratifying its visitors with a specimen of its power.

Near the Geyser is another thermal spring, the Strokr, which is liable to eruptions of steam and water on a large scale, but at very irregular intervals. This spring first broke out in the year 1784, on the occasion of the great earthquake.

Several smaller thermal springs in the neighbourhood present considerable attractions to the visitor by their curious and interesting phenomena. The so-called Little Geyser is situated in a separate group of hot springs, about thirty-six miles away from the Great Geyser. Its eruptions take place on an average at intervals of about three hours and a quarter. They are preceded by an increased development of smoke and a splashing noise underground. Then comes a rush of boiling foam, rising and falling at intervals, ascending higher each time, until in about ten minutes, when the crisis of the scene occurs, it sends up sheaf-like columns of steam and water to the height of thirty or forty feet. The feathery streams then decrease as gradually as they rose, and in another ten minutes the geyser has regained its usual state of repose.

In the island of New Zealand the geysers are seen on a much more imposing scale than in Iceland. More than five hundred hot springs, and several boiling eruptive springs, are found there within an area of about two square miles. The Maoris call the geysers *puia*, and the hot springs *ngawah*. The grandest of these springs are found in the river valley of the Waikato, in the region of the *puias* of Crakeikorako, where their appearance has been thus described by Hochstetter, who visited the valley in April, 1859. What a magnificent sight! he writes :—

"Rushing along at tearing speed, forming rapid upon rapid, the Waikato precipitates itself into a narrow pass enclosed between steeply rising mountains ; its waters whirl and foam round two little rocky islands lying in the centre of its bed, and then dash outward through the narrow valley. Along the banks rise white vapour clouds from the hot springs which empty themselves into the river, and from caldrons of boiling water enclosed in masses of white rock. Here a steaming fountain shoots up and falls again through the quivering air, there rises another, while at a third place two start together, one low down, close to the shore, and another on a rocky terrace ; and thus the play of cloud and water continues, as if some one were trying the experiment whether all the springs could flow, and all the fountains find water enough to rise at once. I began to count all the places where



Hot Springs in the Waikato Valley.

a boiling spring was visible, or indicated by its hovering vapour cloud. I could not overlook the whole area, but I counted seventy-six, and among these were many intermittent geyser springs, which break out into sudden eruptions. The sketch I made on the spot can only give a faint idea of the grandeur and uniqueness of the scene, and no mere description can at all do justice to it.

"The district of these hot springs extends for about a mile on both sides of the Waikato, southward to the foot of the steep rocky slope Whakapapatarniga, and northward to the wooded mountain of Tutukau. Most of the springs lie upon the right bank of the river, which is very difficult of access, as the river cannot be crossed near the springs, but only above or below them, and then the traveller has to clamber along the steep projections of rock overgrown with brushwood which overhang the shore, and where one is by no means sure of not sinking at any moment into some treacherous pit of boiling mud. I was obliged therefore to limit my observations to the left bank and the springs which lay immediately below the village.

"A rocky plateau, one hundred and twenty paces long and the same in width, formed of silicious sediment, and called by the natives Papa Rohata, or the flat rock, extends its slooping plain from the foot of the mountain to the river. This literally 'bubbling caldron' contains all the most important and interesting springs of the district. One of the springs, which lies on a slight elevation of ground, not unlike a bubble thrown up upon the bottom of the caldron, discovered its intermittent qualities in a way which showed me how dangerous it is to approach this locality without having secured the services of a competent guide. My two companions wished to indulge themselves by taking a bath in the Waikato, and had just laid down their clothes near one of the hot wells, when they heard a sudden detonation, and the waters in the basin were violently agitated. My friends sprang back in alarm, and were just in time to escape a shower bath of boiling water, for a huge column of water rose in a slanting line with a hiss and a roar from the pit, and reached a height of twenty feet. My companions in great excitement told me of their adventure with the malicious geyser; but when I reached the place, all was quiet again, and I saw nothing but the crystal clear water gently welling up in its circular basin of four or five feet in diameter. The temperature stood at 201° Fahr. The reaction was perfectly neutral, and the water tasted like weak meat soup.

"The first eruption I witnessed happened on the following morning, at twenty minutes past eleven. Just before it took place, the basin was full to the brim. A sound of rushing and bubbling was distinctly heard in the depths below, the water on the surface boiled faster and faster, and suddenly shot up with great force at an angle of seventy degrees in a south-easterly direction to a height of twenty or thirty feet. Immense volumes of steam rose up together with the water, partly veiling the sheaf like a column within. The eruption continued in full force for a minute and a half, after which the violence gradually abated, and in two minutes the whole disturbance died away with a gurgling sound far below the surface of the earth. I came up to the edge of the well, and found it empty. I was able to look down for about eight feet into a deep funnel-shaped hole, from which hissing jets of steam were still rising. Gradually, however, the water began to rise again, and in ten minutes the basin was full.

"The second eruption occurred at five and twenty minutes to two in the afternoon, and the third at ten minutes past three, from which I concluded that they succeed each other at intervals of about two hours. The deposits from these and all other similar springs are silicious in character, the fresh deposits being soft and gelatinous, which gradually harden to a friable substance which feels like sand, and finally form horizontal layers of solid stone, presenting the most varied features of form and colour in different places."

To the north-east of this district lies the Rotomahana, or warm lake. Hot springs rise up from its bed, and round its bank is a continual hissing and bubbling, so that one has only to dig a little in the earth to find a furnace of boiling water hot enough for cooking purposes.

"The wonder of wonders belonging to the surroundings of Lake Rotomahana is a magnificent geyser which extends with its terraces of silicious deposits far into the lake. It is called Te-tarata, and lies on the north-eastern shore of the lake. On a hillside overgrown with fern, and rising some eighty feet above the lake, showing here and there reddish patches coloured by oxidised iron, and sending out clouds of vapour, lies the principal basin of the Geyser. The basin is shaped like a crater, open towards the west, with clayey walls thirty or forty feet deep. It is about eighty feet long and sixty broad, and filled to the brim with clear transparent water, which looks wonderfully blue against the snowy whiteness of the basin; the blue, not of the turquoise, but of the opal. At the margin of the basin the temperature stood at 183° Fahr., but in the centre, where the water rose perpetually to a height of several feet, it is boiling hot. Immense clouds of steam, which reflect the beautiful blue of the water, whirl round and veil the view of the whole surface, but the noise of the bubbling and hissing can be always distinctly heard. The native who was acting as my guide told me that sometimes the whole mass of water was hurled with great force into the air, so that any one on the spot could look down the empty basin to a depth of thirty feet, but the water soon filled it up again.

"Eruptions of this nature, however, occur only during the prevalence of long-continued and violent east winds. It would be very interesting to have these statements confirmed; for if they are true, the Te-tarata spring is certainly an intermittent geyser, breaking out at long intervals into eruptions which equal those of the Great Geyser in Iceland. The basin of the great Te-tarata is much larger than that of the Icelandic geyser, and the mass of water thrown out must be of immense size and weight. The water has a slightly salt but by no means an unpleasant taste, and is in the highest degree capable of petrifying, or more correctly, of incrusting objects exposed to its influence. The deposit, like that of the Icelandic springs, is silicious *débris* or tufa, and the overflow of the spring forms terraces of the same formation, white as if hewn out of marble, and presenting an appearance which surpasses all description. It seems as if a waterfall were suddenly frozen into stone in the act of falling over terraced steps.

"The wide shallow base of the geyser extends far into the Rotomahana, where the terraces begin with shallow deposits broken up by small basins or cavities. Higher up, the terraces are higher, some of the steps being two and three feet, and others four and six feet in height. Each of these steps has a small raised margin, from which stalactite formations hang down toward the step below, and enclose a level platform, varying in width, and containing one or more basins filled with water of the clearest and most brilliant blue. These basins form the most luxurious and inviting bath-rooms possible. The bather has a choice of baths of every size and every temperature, from the hot waters of the lower steps to the colder ones above, and some of the basins are large enough to form a good-sized swimming bath.

"From the foot of the Te-tarata spring a path leads down through the thick copse of the hillside to the great Ngaha-pu Geyser. It lies about ten feet above the lake, shut in on every side by bush and thicket. The immense column of steam perpetually rising from it betrays its position at a great distance. The basin is oval, forty feet long by thirty wide, the water clear and transparent, but always violently agitated. It is never still for more than a few seconds at a time; but boils and wells up from beneath, now toward one side, now toward another, white with foam, dashing up jets of water eight or ten feet high, and rolling with fury its surf of boiling and hissing waves toward the brink of the basin, so that the spectator draws back in alarm. The raised edge, however, prevents the water from pouring over the sides of the monstrous caldron. The water of this spring is drawn off by the natives into several artificial bath-rooms made in the stone itself. The thermometer showed a temperature of 208° Fahr.; and the water, when poured over a sheet of blue litmus paper, coloured it with a faint reddish tint. The deposits from this spring are of a dirty brown colour, and at the back, toward the hillside where steam issues from the fissures, sulphurous incrustations are found. Next to the great Ngaha-pu spring lies the caldron bed of the Te-takapo, a hot spring close to the southern side of the shore. It is ten feet long and eight wide, filled with clear water, of which the temperature is 204° Fahr. Sometimes the water from this spring rises thirty or forty feet in height.

"The numerous small springs, mounds of boiling mud, and cylindrical slightly incrusted holes lying on the shore between Te-tarata and Te-takapo have no special name. A few deserted huts are found at Te-takapo, and farther on the valley or pass of Waikanapanupa, or colour-changing water, is reached. This valley extends in a north-easterly direction for about a quarter of a mile, and in the background lies the *green lake*, or Rotopunamu. The access to the valley is overgrown with copse wood, and rather difficult; great care is necessary to avoid the doubtful places where there is a danger of sinking into the hot mud. The valley itself looks like the crater of an extinct volcano. The bare walls of rock, stripped of every sign of vegetation, are frightfully torn and rent; jagged peaks hang threateningly overhead, in menacing, fantastic forms, the last remnants of the original mountain range, torn and split asunder by the restless jets of boiling steam that shoot out from every rift; their crags of red, white, and blue clay present a weird and spectral appearance. The ground of the valley is formed of fine mud, with masses of rent and broken *débris* lying around like blocks of ice after the fall of a glacier. In one place lies a pit of boiling slime, in another a deep caldron of seething bubbling water, in another a fearful chasm sending up clouds of hissing steam."

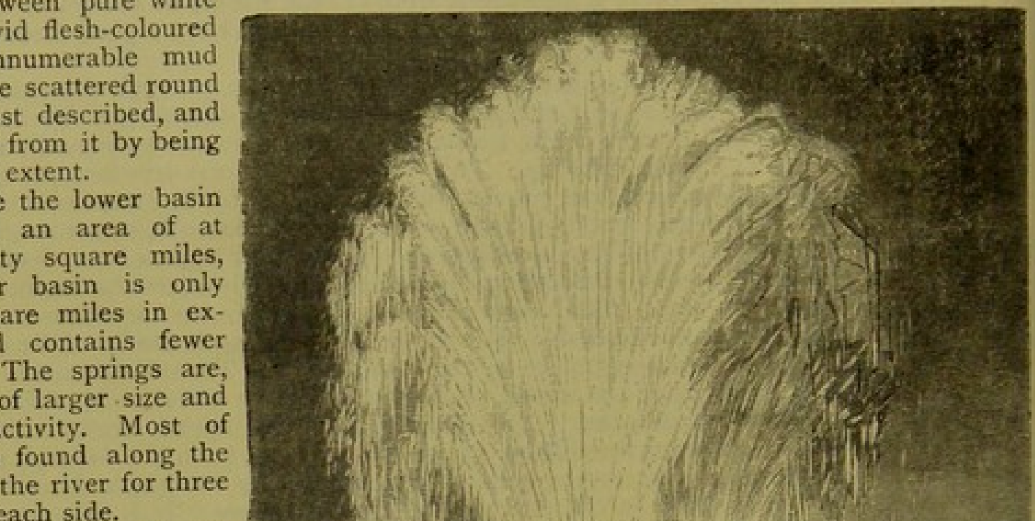
The scenes just described in New Zealand are, however, surpassed by the recently explored "Wonderland" on the Upper Yellowstone in North America. Vague rumours of this remarkable country had been heard as far back as 1854, but the attention of the public was not thoroughly roused till about sixteen years later, when General Washburne published his report. The government of the United States then sent out a geologist to examine and report upon the place, and valuable information as to the hot springs and geysers of the neighbourhood was obtained. There exist, we are told, two separate areas, one situated upon a little tributary of the Yellowstone, the other extending along the Fire Hole River. The latter is the more important, and is divided into two parts, the upper and lower basin.

The region of the lower basin presents a striking appearance in the early morning, shortly before sunrise, when the steam rises from a hundred springs, as if from the chimneys of a manufacturing town. One of the springs, "Thumping Geyser," owes its name to the dull thuds with which the rise and fall of its contents are accompanied: a beautiful vandyked margin rises round it, and numerous smaller basins are scattered near at hand. Farther off are a larger number of geysers of various sizes, sending up jets of water from two to ten feet in height, or boiling in a state of constant unrest, with a measured rise and fall like the beating of a pulse.

To the south of Thumping Geyser is a large basin, 150 feet in extent, in the centre of which is a crater twenty-five feet in diameter, sending up a column of water thirty to sixty feet high, which breaks up and falls back in cascades of silver drops, spreading out on its descent like a fountain, and covering a radius of at least ten feet. A little to the south of this so-called Fountain Geyser boils and seethes a singular mud crater, whose basin measures forty or sixty feet in diameter, and is filled with fine powdery mud. The surface is covered with large bubbles, which hurl the mud with a loud noise high in the air, when they burst; and as there are from twenty to thirty bubbles formed at once, the process is repeated every second, and produces a constant detonation. The mass consists of silicious clay of every shade between pure white and a vivid flesh-coloured pink. Innumerable mud springs are scattered round the one just described, and only differ from it by being smaller in extent.

While the lower basin comprises an area of at least thirty square miles, the upper basin is only three square miles in extent, and contains fewer springs. The springs are, however, of larger size and greater activity. Most of them are found along the banks of the river for three miles on each side.

“Soon after our arrival,” the report continues, “we witnessed a magnificent spectacle. A low thunder roll was heard beneath our feet, the earth trembled in every direction, and suddenly from a crater near the river-side a column of steam shot high into the air. It was followed in a succession of sudden shocks by a jet of water apparently ten feet in circumference, which rose to a height of two hundred feet, while the steam towered above it to more than one thousand feet. It would be difficult to describe our excitement during the development of this phenomenon; if we had been several days in the place, and in some measure prepared for the sight, it might have been possible to watch in silent admiration the wonderful grace and beauty of the mighty column as it rose to the giddy height above during a space of twenty minutes. After the eruption the water sinks a few inches in the basin, and the temperature falls to 149° Fahr.



Geyser of the Upper Yellowstone. Crater of the Great Geyser.

“None of the geysers in the valley seemed to us to equal the Great Geyser, whose crystal waters pour forth from two openings. For ten feet around are found masses of silicious earth, varying from a few inches to three feet in height. They look like spongy corals; the bottom of the basin is covered with similar decorations, and the margin is most daintily adorned with pearly fringes. Outside the basin are several small reservoirs, each surrounded by its delicate white border. They are filled with transparent water, and are from one and a half to three feet wide, many being triangular in shape. As the water slowly filters through, the evaporation forms broad shallow basins tinted with the most delicate colours by the deposits which sometimes take the form of sponges, and every one of the countless little channels delights the eye with its charm of colouring. The great opening appears to boil up about every twenty minutes, and to send up the whole mass of water from ten to fifteen feet high into the air ; but although both the openings are within the same enclosure, we could not be certain that there was the slightest connection between them. When the larger opening is in commotion, the Great Geyser shows no signs of agitation; both seem to work entirely independent one of the other. The Great Geyser sent up two bursts of water during our stay, at an interval of thirty-two hours ; it is not regular in its eruptions, and can only be accurately described by observations extending over several days. Our search after fresh wonders led us up a slightly incrusted slope above Fire Hole River, where we found ourselves on the edge of a great oval chasm, eighteen and twenty-five feet in diameter, and enclosed by a jagged border and rough side walls of greyish white silicious crust, visible to a depth of one hundred feet. We could see no water, but we distinctly heard it gurgling beneath our feet. Suddenly it began to ascend; great clouds of boiling steam rose up, and scared our party away in hasty flight. When the mass had risen to within forty feet of the surface, it seemed to quiet down, and hurrying to the spot we saw it foaming and bubbling below, sending up at intervals slender shafts of water to the brink of the opening. Then, as if seized with a fearful convulsion, it rose with such swiftness, that we had barely time to place ourselves in safety before it shot up sixty feet above the edge of the basin, in a great dome-like mass, from the summit of which five or six columns of water, from six to fifteen inches in diameter, rose to the amazing height of 250 feet. The latter came doubtless through openings placed near the principal mouth. This magnificent eruption lasted twenty minutes, and was the grandest we ever saw. The sun was at our back, and its rays formed countless rainbows of vivid blue, gold, red, and green across the glittering background of the water and the dead whiteness of the steam-clouds. Every instant they broke up in diamond rain, to form new combinations of light and colour; from every shadow thrown by the clouds of vapour upon the central mass of waters came the glorious prismatic tints in wreaths of colour, like the halo of a saint. All our previous experiences were thrown into the shade by this one; and we had the happiness of witnessing two of these eruptions in the space of twenty-two hours. We called this geyser the giantess; it was situated one hundred yards from a low circular mound three feet in height, called the Beehive, which we did not even notice or recognize as a geyser, so completely were we under the spell of the wonders we had just seen, until a splendid outburst of water, lasting eighteen minutes, and rising to a height of 219 feet, convinced us of its claims upon our admiration. The Fan Geyser and the Pyramid are also worthy of mention.

"On our return to the Yellowstone Lake, we followed the course of the Fire Hole River. Early in the morning, as we were preparing to take our departure, the old geyser, which stands sentinel at the entrance of the valley, gave us a splendid farewell. Without a note of warning, it sent up a column of water, six feet in size, 100 or 150 feet high in the air, and sustained it by a succession of shocks at the same height for fifteen minutes, when it sank as suddenly as it rose, and all was at rest within the basin. This geyser is the most to be depended on in the neighbourhood, and, from the regularity of its eruptions, has gained the name of Old Faithful."

If we now turn to investigate the causes of the periodic geyser eruptions, we have but to repeat the supposition we have before put forward, namely, that the central heat of the earth, and the steam which it engenders, has much to do with the phenomena. Imagine an extremely pervious and rifted soil round the geyser, every cavity being connected with the earth's surface by tube-like channels, and volcanic heat prevailing in the depths below. The water penetrates the earth from above, and being heated by the glowing masses, creates vapours, which, in time, owing to their power of expansion, force the water upward through the channels. In the year 1843, an experiment was made to demonstrate the truth of this theory by means of an apparatus specially prepared for the purpose. The cavity was represented by a closed copper vessel twenty inches in diameter, and nine in height. A copper pipe, open at the bottom, and with an opening at the top an inch long and the twenty-fourth of an inch wide, rose vertically from the bottom of the vessel through the lid. Twenty-four quarts of water had been poured into the vessel, which, instead of being heated, as we have been supposing in the case of the geyser, by the introduction of steam, was heated to boiling point by means of a spirit lamp fourteen inches wide, and specially prepared for the purpose. The steam weighed down the water, forced it up the tube, through which it issued in a stream an inch in width, to a height of twenty feet, accompanied with a great development of steam. The lamp gave out such intense heat, that the twenty-four quarts of water began to boil in less than a quarter an hour. Toward the end of the experiment the development of steam was so great that the narrow opening of the tube was not sufficient to allow of its escape, and the safety valve being rather too much weighted, the steam tore asunder the soldering of the vessel, which exploded with a loud detonation, thus imitating by accident the detonation accompanying the eruption of the Icelandic geyser. At first sight this experiment seems to reproduce the whole process of the geyser eruptions, but a closer investigation betrays essential differences between the two. A clearer knowledge of the processes attendant on the generation of steam, and more accurate calculations of temperature taken from the water in the geyser channels, have led to a truer conception of the phenomena.

Bunsen's theory of periodic geyser eruptions explains naturally every process observed during their occurrence. He considers that the eruptions are caused by the construction of the tube or channel, and the formation of unusually large masses of steam in the over-heated water contained in the lower parts of the tube. In Iceland as in North America, in Japan as in New Zealand, the boiling springs run through the same changeless phases of their existence. Every geyser was at first a *reykir*, as the Icelanders have it; that is, a hot vapour spring. By degrees the boiling water, aided by carbonic alkalies, displaced the tufa of the bottom of the spring, loosened the flinty earth, and, on evaporating, left it deposited round the mouth of the well. By this means the well would gradually become surrounded by a mound of silicious earth, with a central pipe or opening through which the water rose. Now, under the pressure of the water in the pipe, a heat of more than 212° Fahr. can be communicated to the water below, without bringing it to boiling point. But if the development of steam created by the influx of over-heated streams from a distance sets in at any given point, and if water is hurled upward by a blast of vapour, the pressure on the lower strata is lessened, and the heated water in the depth below is converted into steam, which throws up great masses of water, and causes the eruption. The mound round the opening of the crater is increased after every eruption. There is therefore a greater pressure of water to be overcome before another development of steam and its consequent eruption can again occur; and if the warmth communicated from below is not sufficient, no eruption can take place. Instead of a geyser, the spring becomes a deep reservoir filled with hot water, in the midst of which the old geyser pipe can occasionally be seen. The causes which produce the geyser eruptions are then the same which occasion the disastrous explosions caused by the bursting of steam boilers.

Mineral Springs.

No spring water in the world is, chemically speaking, absolutely pure. It is always more or less charged with substances which it collects during its passage through the subterranean strata through which it flows, and therefore a spring is distinguished as mineral only when the gases or dissolved mineral substances contained within its waters are directly perceptible to smell or taste.

It was a long time before the simple truth that mineral waters owe their distinctive properties to the dissolved minerals contained within them was universally acknowledged. There was wild talk of impossible underground processes, in consequence of which the substances in the mineral waters were produced without further trouble. This erroneous opinion was defended as late as 1827, and it was said that the presence of mineral substances in the waters of various springs must be regarded as an act of vitality on the part of the earth itself. Another theory asserted that electricity was the cause of their appearance, and imagined that within the mountains resided something like voltaic batteries, which produced, from substances unknown, the effects in question. And yet Aristotle, Pliny, and Galen had long ago declared that the wells contained no other substances but such as they found within the earth.

The truth of this statement was afterwards proved from certain saline springs, when the salt beds which supplied them were reached by direct excavation. In the mines of Auvergne the same carbonic acid gas was discovered, which communicated its properties to some springs near. The mineral components of certain thermal springs in South America are exactly the same as those found in a neighbouring volcano. Breislak condensed the vapours rising from a volcanic opening, and obtained a mineral water like that of a spring flowing near the place. And in the year 1826, Bischof showed that the presence of mineral waters could be explained partly by their soaking through the mountain strata, and partly by the decomposition of the same strata by means of carbonic acid gas.

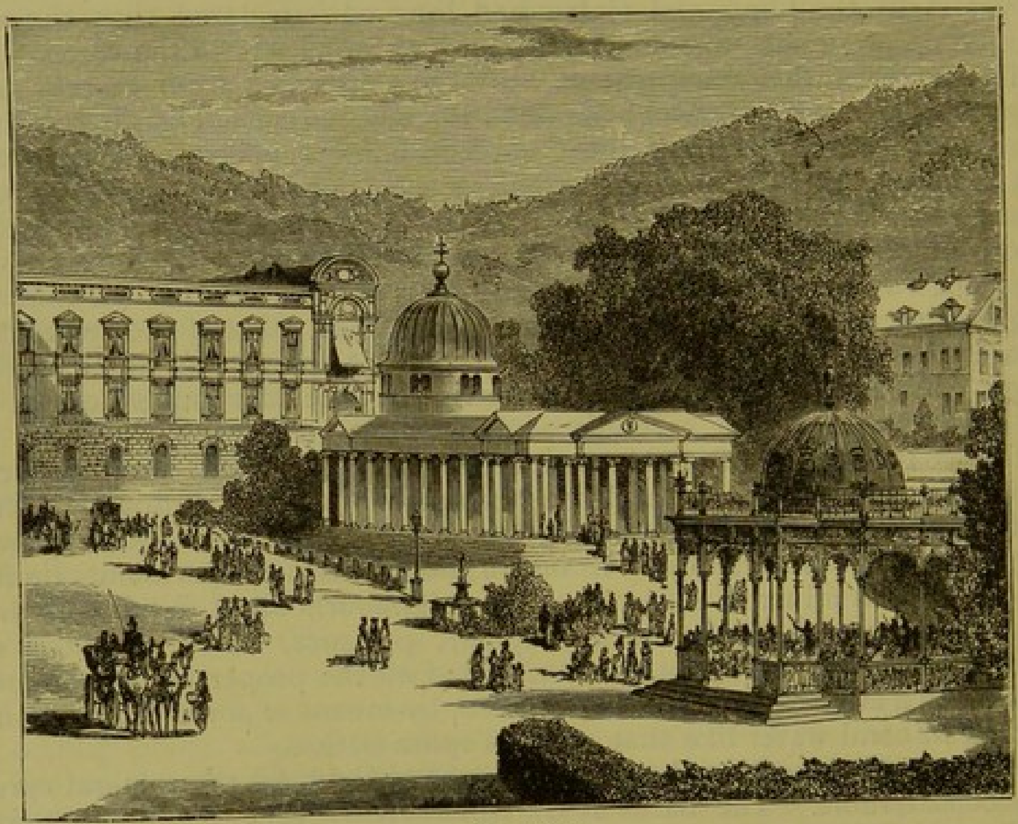
The manufacture of artificial mineral waters, which are, chemically speaking, exactly like the natural ones, has placed beyond all doubt the truth that the mineral springs are caused by soaking and decomposing the minerals through which the waters flow. In one of Struve's early experiments he filled a large tube with minerals taken from the neighbourhood of Bilin, and drove through it, by means of double atmospheric pressure, water saturated with carbonic acid. The water obtained exhibited all the properties of the springs at Bilin. In a later experiment he obtained, by means of some porphyry from Teplitz, a mineral water like that of the Teplitz baths.

The quantity of solid substances brought to light by the mineral springs is very considerable. The baths at Carlsbad yield every year 6,095 tons of carbonic acid natron and 10,155 tons of Glauber salt. Among the European thermal springs, the Bath waters hold a by no means prominent place with respect to the amount of solvent mineral substances contained within them; and yet the sulphate of lime and potash, the chloride of sodium and magnesia which they furnish in the space of a year would, if collected together, form a column of fifty yards high and three and a quarter wide. As it is, these substances flow through the Avon into the sea, but if we imagine them deposited round the springs like the silicious strata of a geyser, a mound would be formed which would soon resemble the circular heaps round a volcanic crater. It is estimated that the sulphur springs at Teplitz, in Croatia, have yielded since the historic period of our earth 4,062,000 tons of mineral substances.

The application of mineral springs to medical purposes, and the discovery of their power in relieving many diseases, is of long standing, and gained for several of their number the name of Healing Springs. Thus the

Greeks made use of the Adepsos springs in Eubœa, and the Agamemnon baths near Smyrna; while the Romans frequented the sulphur baths of Baia and the thermal springs of Wiesbaden, Aix-la-Chapelle, etc. In certain cases medicinal springs are distinguished for the purity of their waters, and there are instances of thermal springs possessing almost chemical purity; although, as a rule, from the greater solvent power of heated water, thermal springs are generally mineral springs. The following is the most frequent classification of mineral springs, based, of course, upon the prevailing ingredient found in their waters: Acidulous, Glauber salt, ferruginous or chalybeate, saline, bitter waters, sulphur, and lime springs.

Acidulous springs are distinguished for the amount of carbonic acid gas and carbonate of natron which they contain; and they are generally found



MARIENBAD.

within the region of active or extinct volcanoes. The origin of carbonic acid is always to be sought deep down within the earth, and must be ascribed to the effect of volcanic action. The water which penetrates the earth's surface meets the rising fumes of the gas, and returns charged with it to the surface, where it breaks out as a mineral spring. Numerous acidulous springs are found in the Eifel, especially in the neighbourhood of the Laacher Lake, where their formation can be directly studied. In many places, natural basins are found filled with water on the surface; and when any of the water is drawn out, the rising of the gas is distinctly perceived. About ten feet above the level of the Laacher Lake is a pit, seven feet wide, and from three to four feet deep, in which many little creatures are found killed by the gas, which is at once smelt by any one bending over the surface of the pit. This pit has been known for many hundred years, and may have given rise to the tradition that no bird could fly over the Laacher Lake without being suffocated by the fumes of the gas. Close to the shore of the lake itself, where the water is scarcely a foot deep, bubbles of gas are distinctly seen rising to the surface; and at the village of Wehr, about a mile from the lake, the exhalations of carbonic acid gas are met with on a large scale. In the village just named are a number of mineral springs lying near together, and as there is no outlet for their waters, they form a swamp of considerable extent. In dry seasons of the year, when the tiny grass-covered islands rising above the swamp afford a sure foothold, it is possible to venture upon the desolate spot and observe the action of the gas without risking one's life. In rainy seasons, however, it is very dangerous to attempt crossing the marsh, and a horse has been known to sink below the surface and be suffocated. The roar of the gas, which rises in bubbles as large as a man's head, and sends up the marsh water a foot high into the air, can be heard at a great distance. The enormous quantity of carbonic acid gas and acidulous water which have been rising there from time immemorial is shown by the extensive layers of oxide of iron, which are a source of considerable profit, and of which large quantities are extracted yearly.

The acidulous springs may be divided into pure, alkaline, and muriatic-alkaline. The pure springs are rich in carbonic acid, but have few other ingredients; they are effervescent, and form an agreeable beverage for the table. Their number is very great, and among the best known are those of the Rhine and its adjoining valleys, which furnish the Heppingen, Lamscheid, and Apollinaris waters; the Marien spring in Bohemia, and the spring at Dorotheen-Au, near Carlsbad.

The hot and cold alkaline springs enjoy a widespread and well-merited reputation for their medicinal properties in relieving certain diseases.

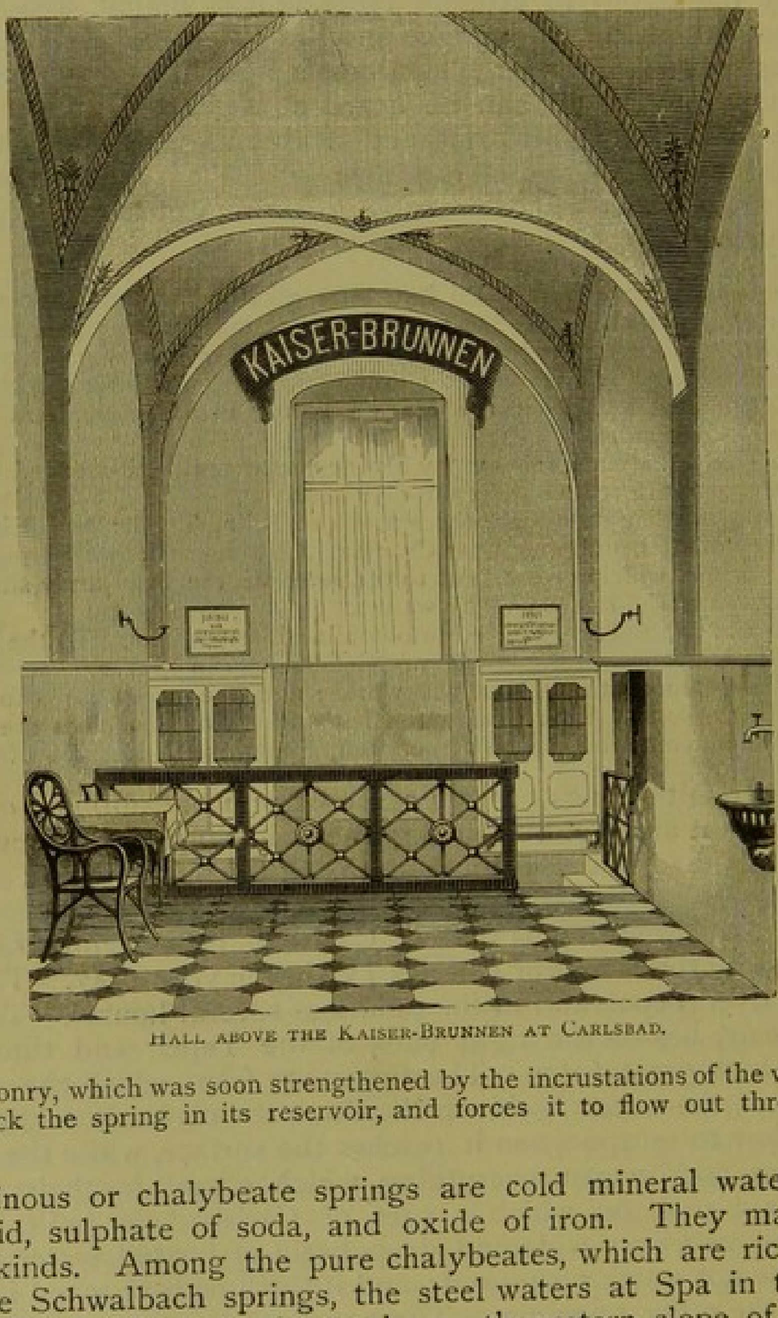
Among the cold alkaline waters are the springs at Bilin, Teplitz, and Elopatak in the wild romantic valley of Siebenburgen, near Cronstadt. Among the hot springs are those of Mont Dore in Auvergne, which were known to the Romans, the beautifully situated thermal springs of Neumahr, and the famous Vichy waters.

The muriatic-alkaline are also divided into cold and hot springs. To the former belong the waters found in a meadow in the village of Niederselters in Limburg, which have made the name of Seltzer famous throughout the world; and the two springs in the beautiful vale of Roisdorf, near Bonn. First among the hot springs of this class are the baths at Ems, and next to them come the famous Kraenchen, Fursten, and Kessel springs.

The Glauber salt springs contain carbonic acid andsulphate of soda, and are divided into hot and cold. Among the cold springs are several at the well-known Marienbad, the Elizabeth spring at Ofen, and the Tarasp waters in Graubunden.

The principal hot spring is that of Carlsbad in Bohemia, said to have been discovered by the Emperor Charles IV., in the year 1347. These springs abound in the river Tepel, and in the cellars of several houses. The principal spring, or *Sprudel*, lies on the right bank of the Tepel, and throws out its boiling waters with great force. The limestone from which the spring rises is the creation of the water itself, which allows the carbonic acid absorbed in the depths below to escape when it reaches the surface, while the particles of lime sink down and incrust everything which comes in their way. This Sprudelstein is a rock on which a part of Carlsbad is built, and which probably lies above a very wide and deep basin of heated water. Wherever it is pierced, the hot water rushes out; and if the flow is checked in one place, it increases in the other openings. The openings themselves are cleaned out from time to time, and freed from their incrustations.

Berzelius has recorded some very interesting particulars as to the extent of the deposits of these thermal springs. In the years 1713 and 1727, he says, the crust of lime from which the waters rise was burst asunder, and the hot floods poured into the river Tepel. In order to find out the cause of the disaster, and to prevent its recurrence, if possible, the rock was pierced; but scarcely was the outer crust laid open, when the hot water rushed out with great violence, and revealed numerous cavities of different sizes, all filled with water, and lying on a second crust of lime. This crust was then broken through, and a third layer was discovered, on which rested similar hollow cells filled with water. On breaking through the third crust, the great basin of the so-called Sprudel Caldron was discovered. The layers of limestone were from one to two ells thick, and consisted of a stone of alabaster whiteness, edged sometimes with brown. The water in the caldron was boiling with a loud bubbling noise, and the amount of steam sent up from it was so great that it was impossible to determine the extent of the reservoir. Reckoning by the formation of the ground, it seemed to be from three to four ells deep, but the width could not be ascertained. The opening was then closed



HALL ABOVE THE KAISER-BRUNNEN AT CARLSBAD.

over with masonry, which was soon strengthened by the incrustations of the water, and which still keeps back the spring in its reservoir, and forces it to flow out through its proper channels.

Ferruginous or chalybeate springs are cold mineral waters containing carbonic acid, sulphate of soda, and oxide of iron. They may be divided into many kinds. Among the pure chalybeates, which are rich in carbonic acid, are the Schwalbach springs, the steel waters at Spa in the Ardennes, and the springs at Liebenstein, on the south-western slope of the forest of Thuringia. Among the saline and alkaline chalybeates, which also contain carbonate and sulphate of natron, are Franzensbad and the famous Cudowa in Glatz. The earthy saline chalybeates contain also sulphate of lime. Among these are found the waters of Pyrmont, the steel springs, the Brodelbrunnen, and the Helena springs; together with four springs at Rippoldsan in Kinzigthal, the springs at St. Moritz in the Upper Engadine, at Wildungen in Waldeck, and many others. Springs containing large quantities of sulphuric oxide of iron are found at Alexisbad in Anhalt, at Muskau in Niederlausitz, and other places.

Saline springs contain principally common salt with several combinations of chlorides, oxide of iron, iodides, and bromides. Salt springs, from which common salt can be manufactured, are called in Germany *Soolen.*

Among the pure saline springs are those of Kissingen and Hamburg, which are cold, and the hot springs of Aix-la-Chapelle, Kissingen, Baden-Baden, Metradia, Burscheid, and Wiesbaden. The springs containing iodides and bromides are found at Hall in Steyer, Salzbrunn, and Kreuznach.

Saline springs are found in all parts of the world. Sometimes the amount of salt which they contain is very small; but occasionally springs like those of Luneberg are met with, which are almost saturated with salt.

FRANZENSBAD.

The thermal springs in the valley of Tuzlassu, near Troy, are among the most remarkable. The hot water filters through the surrounding walls of rock, forming incrustations on all sides, and covering the ground with layers of salt, so that it looks as if covered with snow. On advancing farther along the desolate plain, the traveller finds himself confronted by a precipitous wall of rock, from which a steaming torrent of a strong solution of salt falls in a projecting curve into the valley below, and, joined by some smaller streams, forms a lake of boiling salt water, which winds through the dark masses of the rocky ground.

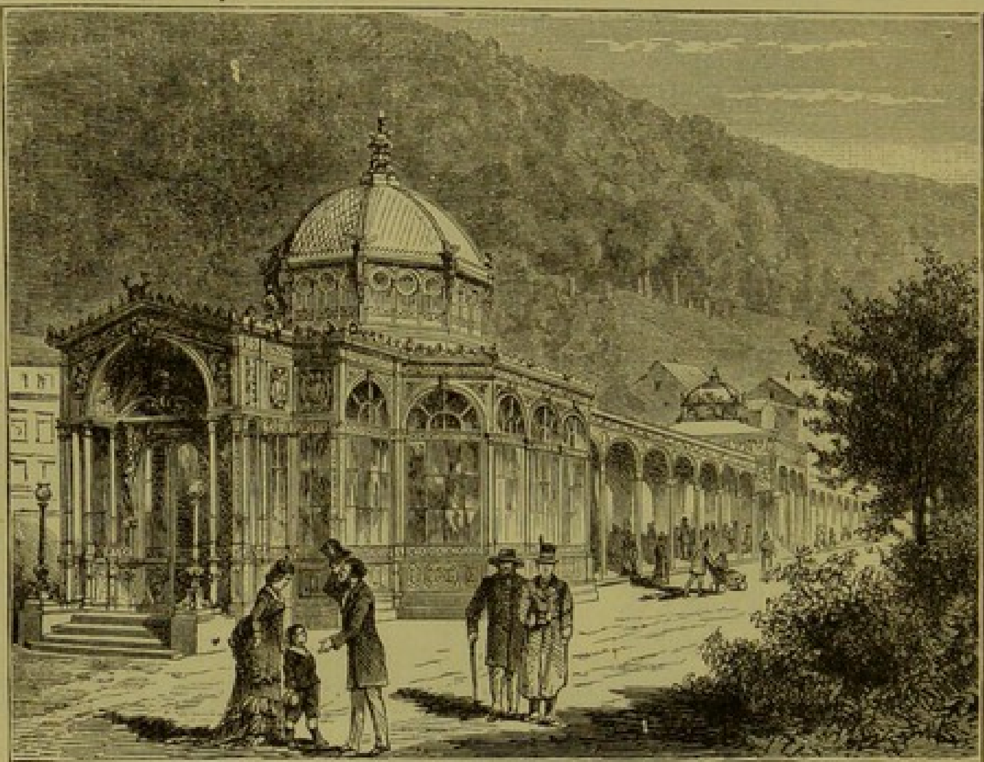
The natural solutions of salt from these springs are used for the extraction of common salt. It is, however, necessary to lead the saline waters into separate channels to prevent their being weakened by the entrance of fresh water. The great strides made of late years in the knowledge of this subject have led to the rejection of the weak natural saline springs, and the procuring much purer, and a greater abundance of common salt, by penetrating to a greater depth below the surface.

The bitter waters have very little carbonic acid, and large quantities of bitter and Glauber salts. Among these are the Friedrichshal waters found in Meiningen, the Hunjadi-Janos at Ofen, the springs of Pulna, between Teplitz and Carlsbad, and those to which the uninviting village of Saidschutz in Bohemia owes its fame.

The sulphur springs are known by their strong odour of sulphuric hydrogen. Best known among this class are the springs of Baréges, in the Pyrenees, Bagnères de Luchon, in the department of Haute Garonne, Henstrich Bad, in canton Bern, and others.

The lime springs contain principally carbonate and sulphate of lime and chloride of calcium. There are cold and hot springs of this kind. Among the latter are the famous thermal springs of Leuk in canton Wallis.

The deposits of the carbonate of lime cast down by the water in which



WILDBAD.

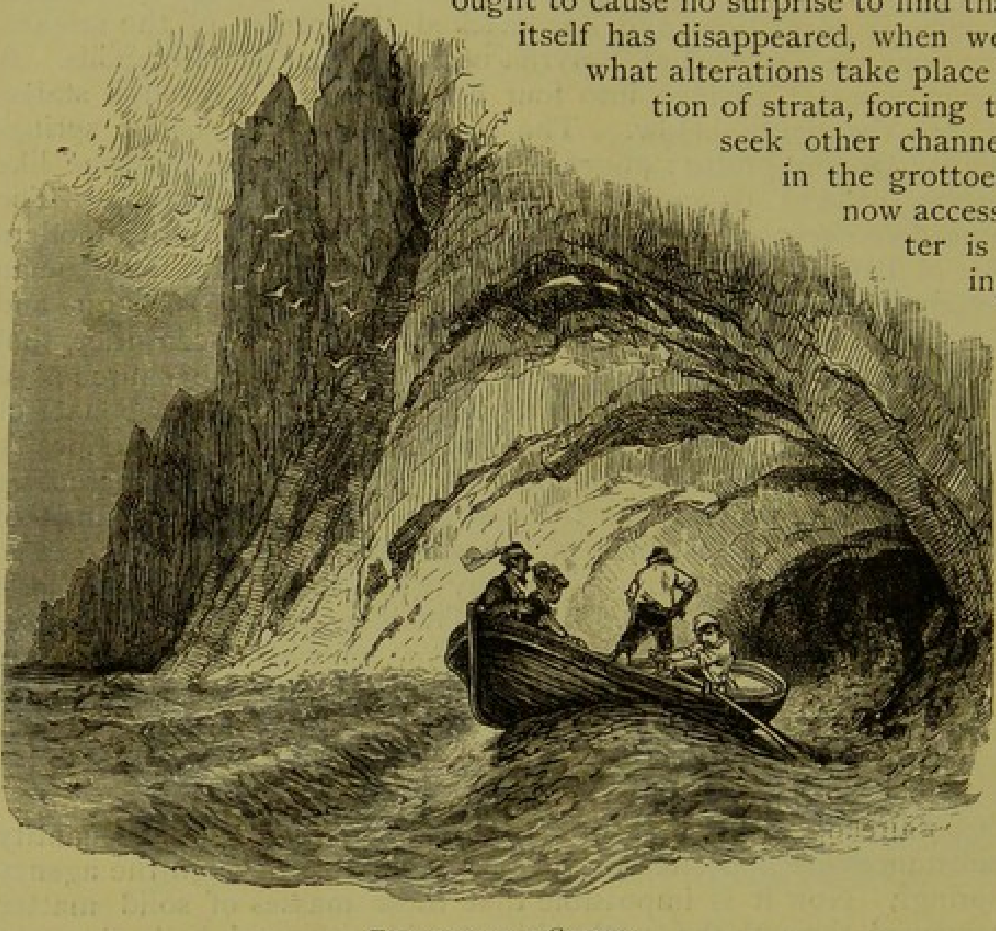
it is found form extensive beds of lime-tufa; the layers are so quickly formed by this class of springs, that they are sometimes called by the name of *incrusting* springs. The effects of this incrusting power has already been noticed in our account of the Carlsbad waters, which have formed the ground on which a part of the town rests, and which rapidly encrust every object exposed to their influence. Extensive deposits of lime-tufa are found in the Hartz and in the Thuringian forest. They form with such rapidity, that it is often necessary to re-open the channels of mill-streams through which the waters have been led. Among the ancients we even find legends of watercourses which build their own bridges. The thermal spring of St. Alleyre at Clermont in Auvergne presents an instance of this. Its outflow was gradually surrounded by its deposits of lime-tufa to such an extent that it grew at last to an immense stone wall, over the top of which the water spread out and flowed on its way. It received the name of *Pont natif de*

St. Alleyre, because, as it continued growing, it came to the bank of a brook, the waters of which prevented the deposit of the earth in its bed, but allowed it gradually to cross it, and continue its way on the other side. An opening was afterwards made in the bridge for the spring water of the brook, and the wall was found to be more than four feet wide, and many feet deep.

A formation of the same kind, but on a larger scale, was found between Erzeroum and Trebizond, on the north of the Taurus. A hot spring with a strong development of gas broke out from the side of a limestone hill, and built across a river an arched bridge of tufa and stalactite, beneath which the river quietly flows on in its accustomed course. This natural bridge is now covered with earth and vegetation. Farther down the river, a second bridge of the same kind is in course of formation, and has reached the centre of the stream. Curious formations are also seen at Smyrna near the ruins of Hierapolis. A powerful stream of water, divided into four branches, rushes through stalactitic groups into the depth below. The stream seen from below springs foaming from its gloomy grotto; above it are fantastic groups of stone like gigantic weeping willows or chalk-white woolly-looking stalactites. The weird, phantom-like effect of the whole is quaintly expressed by its modern Turkish name of Pambuk Kalissi, or Cotton-wool Fortress. In the Roman aqueducts which are continued from the heights of the Eifel to Cologne and Trier, the deposits have so greatly accumulated in the course of centuries, that columns sculptured of their stone are sometimes found in the churches of Eifel. The deposit has been pronounced to be an almost pure carbonate of lime. The Italian chain of the Apennines furnishes rich material for deposits, and in that region there are found not only incrusting wells, but incrusting rivers, such as the Anio, which forms the cascades of Tivoli. All kinds of small objects are exposed to the spray of the waterfall, and returned to their owners or sold to strangers covered with tiny glittering grains which look like crystal, and are called *Confetti di Tivoli* (Tivoli sweetmeats). The *lapis tibertinus* of the Romans, now known as *travertine,* of which the Colosseum and many of their greatest buildings were made, is found in large quantities at Tivoli.

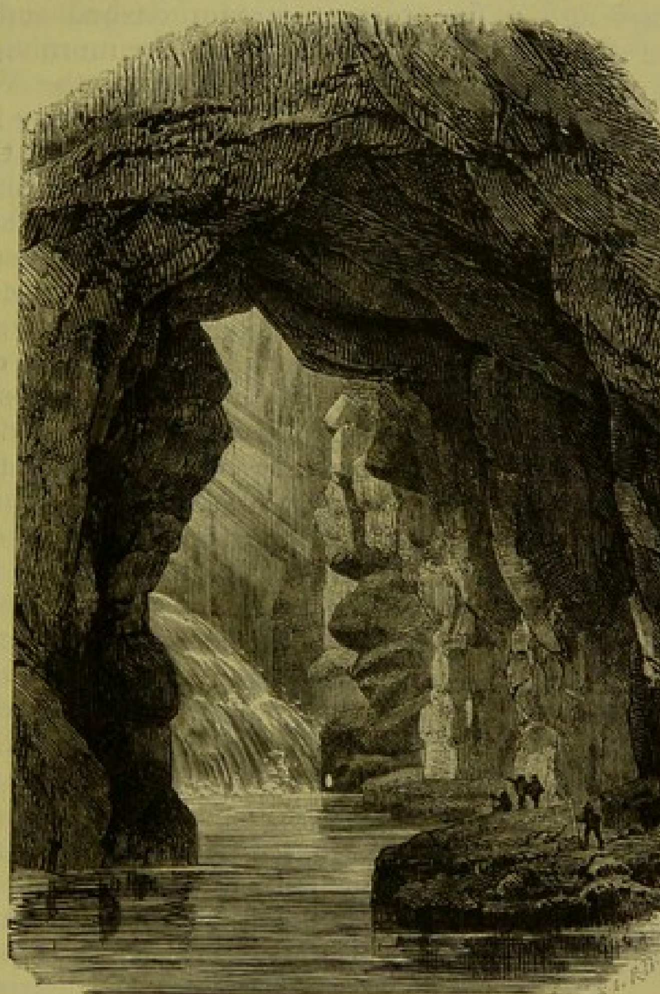
Underground Watercourses—Grottoes.

It has been already stated in a preceding chapter, that a great quantity of mineral substances are deposited on the earth's surface through the agency of mineral springs. Now it is impossible that these masses of solid matter should be conveyed through the earth without widening and hollowing out the channels through which they pass, and so forming from time to time large basins or reservoirs filled with water. The springs at Nauheim yield every year 1,080,000 cubic feet of salt, and as they have flowed from time immemorial, the imagination can scarcely realise the excavations they must have formed within the interior of the earth. According to one estimate, these springs, judging by their present water supply and their yield of salt, must take up in a period of four thousand years a space equal to that of the river bed of the Rhine between Bingen and Coblenz. We know as an historical fact that these springs have been flowing for almost two thousand years, and no geologist would hesitate to say that their age is even greater than four thousand years; we can imagine therefore how vast must be the cavities existing beneath Nauheim and the surrounding country. How deep and of what shape these cavities are we cannot tell, but we know that they are there, and we assume that they are filled with water. The substances dissolved and carried along by the waters are principally rock salt, limestone, dolomite, and gypsum; and it is therefore of these materials that the underground caverns and recesses are principally formed. In olden times the wildest suppositions were current as to the origin of these caverns; but at the present day almost all authorities agree in looking upon them as the work of underground waters. The only exceptions are certain cases in volcanic districts, which, however, never attain the grand proportions of those we are now considering. There are many grottoes which are not now distinguished by water flowing through them, but which still bear the imprints of former rushing streams, which have left sand and broken fragments of *débris* behind them. It ought to cause no surprise to find that the water itself has disappeared, when we remember what alterations take place in the position of strata, forcing the water to seek other channels; indeed, in the grottoes which are now accessible the water is seen striving to make its way downward through lower strata. Most caves present the appearance of vaulted halls, connected by means of narrow clefts or channels with similar halls situated above or below them.



ENTRANCE TO A GROTTO.

The chief beauty of the limestone caves is the stalactitic formations which are seen assuming the most fanciful shapes on the walls and ceiling of the cave. The imagination need lend but little aid to see in them now mighty organ pipes, now cataracts frozen midway in their fall, now towers and colonnades, or delicate lace-like draperies hanging unstirred by any wind. The origin of all this fairy world is simple enough. When the water laden with carbonate of lime hangs in drops from roof or wall, the particles of lime are separated, and form, in course of time, spears and icicles of stone, which are generally known as stalactites. The water dropping from them is by no means free from lime, and the latter, accumulating on the spot where it falls, forms upward-pointing spears called stalagmites, to distinguish them from the downward-pointing stalactites. Supposing this process to continue for a sufficient length of time, we see that the stalactite and the stalagmite must meet, and so form the wonderful organ pipes, whose delicate beauty of form delights the spectator. But long, long ages must pass away before such architectural trophies of the under world are completed. From calculations made respecting the age of a certain stalagmite known from its shape as the Jockey Cap, it was found that its yearly growth amounted to no more than 0·3 of an inch. At the beginning of the present century the skeleton of a human being was found in the Adelsburger Cavern. It belonged probably to some unfortunate man who was unable to find his way out of the labyrinth of underground passages. When discovered, it was completely covered with stalactites. From experiments made with the water dropping upon a stalagmite in a cavern in Franconia, it was found that in twenty-four hours the amount of lime so accumulated was only 0·706 of a dram, and that therefore it would take more than 2,000 years to collect a cubic foot of such stalactitic stone.



RIVER IN A CAVE.

Many such subterranean grottoes exist in Germany, the most famous being the Gailenreuther Cave, near Goszweinstein. It has several stories and separate chambers and galleries, and scientific writers agree that in distant ages it was the home of lions, bears, and hyenas. It is now easily accessible, as is also the cavern of Muggendorf, discovered by Professor Rosenmuller in 1793. Less known and more difficult of access are the subterranean chambers and corridors of the highlands of the Altmühl Alps. To the south of Raintenbuch, on the outskirts of a wood, is the so-called *Hohloch* (High Cave), named by Doderlein as "the astonishing man and beast devouring cavern." It is from eight to ten feet wide, and supposed to be seventy feet deep. On summer noons, when the sun's rays strike more vertically within its depths, hollows and vaults are seen through the perforated side walls. How it looks below, no one can say: there is a tradition that numerous passages and corridors open out from underneath. These cavities have much to do with the landslips which are called by the people of the neighbourhood, *reindeln*. The number of these landslips increases as time goes on, and now they occur at places where they endanger the dwellings of the inhabitants. A few years ago two disastrous landslips occurred; one of them took place near the village of Oberndorf, on the Kheuenhuller mountain at Beilngries, and the place is shown beneath which a whole village lies buried. This is no legendary fable: the village really existed; it was called Frankendorf, and is named in records dated 1305 and 1306, together with Oberndorf and other villages. These landslips point indubitably to the conclusion that in the central heart of the mountain there exist numerous cavities, corridors, and probably wide-reaching vaults, which, if they could be penetrated, would present many objects of interest to the geologist and naturalist. They are doubtless the reservoirs which supply the springs that abound in the valley, and the caves beneath them furnish the masses of water which occasionally burst forth as mountain torrents, and rush down the hillside, to empty themselves in the valley below. About fifty-four years ago a fine torrent stream dashed suddenly from the rocky wall 300 feet above the high road, early on the morning of a fine sunny day, and poured its waters through the ravine known as the Wolf's Gorge, into the valley as far as Altmühl. The stream lasted for thirty hours, and was of such force that some enterprising spirits had time to project the setting up of a mill.

Among the best known scenery exhibiting these subterranean ravines, grottoes, and watercourses, is the desolate inhospitable landscape seen on the chalky plain of Karst. When this rocky desert is seen from the railway, on the line between Graz and Triest, some scattered brushwood, numerous rocky *débris*, and isolated depressions of the soil are visible. It is only when the country is visited on foot that its singular character is rightly appreciated. The visitor first notices the numerous funnel-shaped holes, called *dollinen*, and the strata-like descents, or *jama*, which lead down from the surface to a depth sometimes of more than fifty yards. At the foot of the smooth perpendicular walls are channels and cavities, some of which are more than 550 yards in extent, and may be compared to the craters of volcanoes. Their origin must be ascribed to the falling in of the roofs of underground caves. The soil at the bottom of these depressions is sometimes very fertile, and when overgrown with plants they present a pleasing appearance in the midst of the surrounding desolation, and have been aptly compared to flower pots sunk in the earth. Sometimes the noise of rushing waters is heard from the brink of these cavities; and the Recca, which disappears at the village of St. Canzian, is actually visible again at some little distance, as a wide underground brook, flowing over the bottom of several *dollinen*. It is to be supposed that the whole neighbourhood of Karst is undermined with passages and caverns, very few of which are accessible, but all of which are connected one with another. The Timavo is very possibly the outlet for all the mass of waters collected underground in the southern plateau of Karst.

The most famous cavern of the district lies to the north-west of the village of Adelsberg. It was known in the middle ages, but afterwards fell into oblivion, and was discovered afresh in the year 1806. The accessible portion of this cave is 4,560 yards in extent. It is divided into several parts; the first chamber being the Poik Grotto, through which the river of that name can be traced for a long distance, until it disappears under a wall of rock; indeed, it is possible to descend to the brink, and watch the direction in which it flows into the great cavern under the rocks. The entrance to the grotto is forty yards above the spot where the Poik flows into it, and is reached by crossing two large natural bridges, artificially joined together and leading to the so-called cathedral, an immense vault, the limits of which are lost to the eye in dim twilight, and from the depth the rushing of the Poik is distinctly heard. Farther on is Kaiser Ferdinand's Grotto, discovered in 1816, a suite of chambers decorated with the most beautiful stalactites. Franz-Josef-Elisabeth Grotto, discovered in 1829, leads to the vast hall of the so-called Mount Calvary. Branching passages starting from the sides of this hall lead to other parts of the cavern, the finest of which is the Gothic Hall.

Closely connected with the subject of subterranean caves is the Lake of Zirknitz, known in Strabo's time, and about which the strangest legends have been current. It was said, that in the course of one year, fish were caught, harvests reaped, and game hunted upon its surface; and that its waters, rushing suddenly from unknown depths with the roar of thunder, were the home of strange creatures never seen in any other place. Doubtless many of these myths were originated and kept up by the people of the place, in the hope of rendering the lake still more interesting than it is by its undisputed wonders to its numerous visitors. To turn from these exaggerated statements, we find that the lake is situated a few miles to the south-east of Raket, a station on the southern branch of the Austrian railway, and extends as far as the foot of the Jawornik. Numerous villages surround its waters. It is divided by several peninsulas into different parts, and its banks are shallow in some places, and steep in others. The lake itself is by no means deep, except in the sedgy part called the Leech Pond. Its surface is about nine miles long, and from one and a half to three miles wide. All through the summer months the bed of the lake is quite dry, and serves to store up hay and straw; formerly it was ploughed for crops. In the heavy rains of autumn, and at other times of the year when violent thunder-showers have fallen, streams of water begin to pour through numerous holes in the bottom and sides of the lake, bringing with them sometimes large crabs, pike as long as a man's arm, whiting, tench, and the rare salamander (*Proteus anguineus*). As soon as a certain quantity of water has been poured into the lake, the holes cease to flow.

The lake fills in twenty-four hours, and remains full through the winter and spring till the dry season begins again. As a rule it begins to sink in July and August, and in fourteen days is left quite dry; of course the higher parts do not take so long. Even in the winter, if there is a long period without rain, the lake runs dry. Sometimes it has happened that several years have passed without the lake's becoming dry; but of late, since the large holes in the side have been thoroughly cleared of wood and rubbish, the outflow has been regular.

The lake has also constant tributaries and outlets through several of these holes, and rises and falls like other sheets of water, according to the variations of the rainfall. Continuous rain produces a rise of the lake's surface, but does not cause any flow from the holes. When the lake is dry, the small streamlets flow quietly through the meadows.

The perforated limestone of the Karst is full of these holes, some of them so small that when the lake runs out they are quite hidden by the mud left over their opening, and some of them, especially those in the side of the lake, large enough to afford shelter to sixty head of cattle during the noontide heat. One of them, which is filled full of water at the time when the influx begins, is about eight feet high and eight wide, and pours out of its mouth huge blocks of stone weighing several hundredweight, hurling them to a distance of from ten to twenty paces. The in-rushing streams bring a great quantity of fine mud, which is seen in the deepest places, and even coating the stones. When the lake fills, the waters rush at the same time through the holes in the bottom and in the side, and the fish they bring are never damaged or injured in any way, and are in every respect like ordinary fresh-water fish.

The presence of these fish proves that the reservoir which supplies the lake is open. Ordinary fish cannot live in closed grottoes, and the water which brings them is not lake but river water. There is no lake in the neighbourhood approaching the size which would admit of such variations in the height of its waters as to explain the phenomenon, and none where so great a quantity of water could flow out without being at once perceived by the fall of its surface. Moreover the reservoir cannot be far away, because the fish arrive uninjured, without having even had time to lose their bright colours from want of air; and the difference of level between the waters of the lake and its reservoir cannot be very great, or the stones, etc., would be carried to a greater distance, and the fish would certainly be injured. And it is possible that the same reservoir supplies the inflowing and receives the outflowing waters, because the influx pours through the same holes in the bottom of the lake which form the outlet.

Between four or five miles from Zirknitz, on the other side of a tolerably high chain of hills, flows a stream, the Obrechbach, with such a volume of water, that it is navigable by small boats. After a course of about three-quarters of a mile it suddenly disappears underground, and comes to light again a mile farther on. It now flows for several miles, and is lost again at the little town of Gotsche. Its further course remained a mystery for a long time, but it was discovered at last, and it is now known to empty itself by a subterranean channel into the sea about eleven miles from Triest.

This stream is probably the source of the waters in the Zirknitz lake. It is thought that the Obrechbach or one of its tributaries intersects the level of the shallow lake, so that one part of the reservoir is higher and another lower than the bed of the lake. When the river is swollen by heavy rains, it overflows like any other stream; and as it cannot spread sideward over its banks, it rises up through the numerous channels of the rock, until it can reach the surface, and empty itself into the lake, and doubtless into other openings, where it breaks through as springs which excite no special notice or attention.

The water in the lake must rise to the same height as in the underground pipes which convey it; and when this level is reached, the influx ceases, and the fine mud brought by the river sinks to the bottom of the quiet water. This mud stops up the narrow channels in the bed of the lake through which the water poured; and even if some of them remain open at the mouth, it chokes up the holes lower down, and bars the outflow of the water returning to the river. This fact will have nothing astonishing to those who have observed the force of a torrent, and the quantity of earth it can carry down with its waters.

In dry weather the purified lake water filters through the surrounding rock, which is extremely loose and porous in character, and passes it through like a sponge or a sieve, carrying away the fine mud, thus opening at first small channels, the effect of which is not noticed at once, because the loss of water is compensated by other tributaries, but gradually forming larger openings, through which the water quickly carries off the mud. This process hastens on the emptying of the lake, until at length its waters rush out through the large channels, and the bed is left dry.

Among the caverns and grottoes of the Hartz, the principal are the Biel and Baumann's Caves. The visitor enters them from the little village of Rubeland. Baumann's Cave has been known for more than three centuries, but it has been by no means thoroughly explored. The opinion of an honest writer in the year 1683, that the "cave reaches as far under the earth as the imperial free town of Goslar, which is four good German miles from the entrance of the cave," is as worthy of credence as his subsequent assertion that "many men have been driven round and round the cave for a long time by divers spirits." The best known of the stalactitic formations in the grotto is a column nearly three and a half yards high. The adjoining Beil's Cave was discovered in 1672, and made accessible in 1788. Its most interesting part is the so-called Hermit's Grot.

The Dechen Cave at Letmath, discovered by the laying down of the railway line to Iserlohn, is of moderate size, but equals in beauty the finest

THE DECHEN CAVE AT LETMATH.

underground caverns of Germany. It is divided into several chambers, called by the most fantastic names. The whole district round abounds in similar caverns of great interest and beauty, the best known of which is the great Klutert, near Milspe.

The caverns of Mährisch are very numerous. They were famous in old times for the number of bones of unknown animals which were found within them, and which give rise to many a legend of giants, dragons, and other materials of romance.

The Slouper Cavern, which has been subjected to a searching scientific investigation, is one of the most interesting. It was first mentioned in 1669, when it appears that it had been known for a very long time, and presented a beautiful appearance, until it was robbed of all its stalactites to adorn a neighbouring grotto near Eisgrub Castle. The old historian records at the same time the sad fate of a stonemason who let himself down by a rope into the depths of the cave, and who on his return not only told a wonderful story of mysterious halls, subterranean waters teeming with monstrous fish, and so forth, but who also fell dead the moment he had finished his narration. His fate was sufficient to preserve the cave for a century long from all intrusion on the part of inquisitive mortals, and it was not till the year 1748 that Nagel undertook to explore the underground recesses. A staircase was laid down in the year 1804, on the occasion of the visit of the Austrian Emperor and Empress, but owing to the accumulation of water it was not possible to penetrate far into the cave.

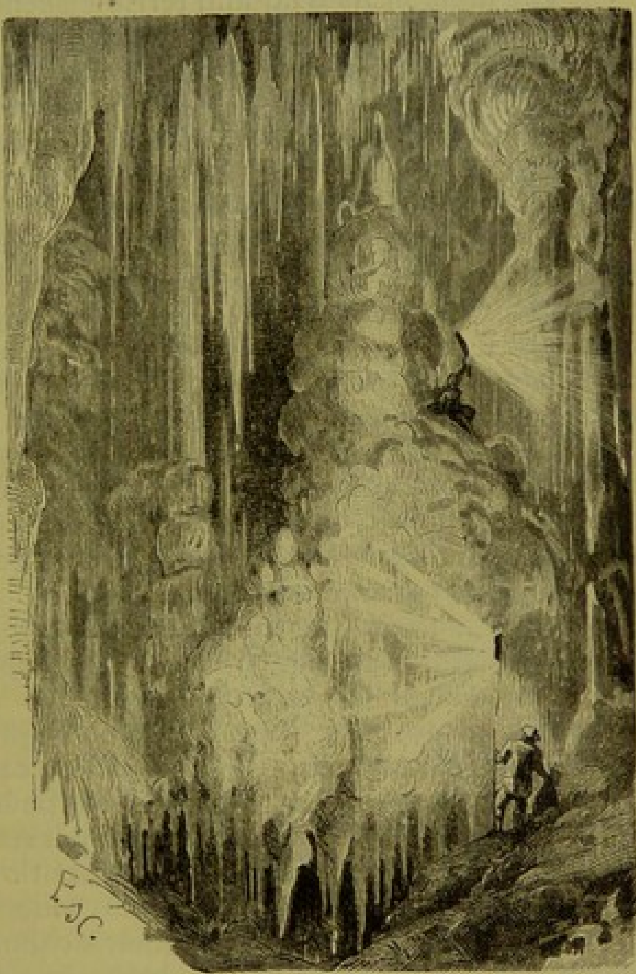
The entrance to the Slouper Cavern is a picturesque basin formed of precipitous, almost vertical, walls of rock, in the centre of which rises an isolated block of porous stone, the only remaining support of some fallen antechamber to the grotto. The cavern is divided into two parts, the Slouper Cave itself and an adjoining chamber on the north-west side, called the grotto of nothingness. Both must once have been more or less filled with water, for there are many traces to show where the water flowed before it found its way into the caverns lying below. The cavern is dirty, begrimed, and bare, showing every sign of the vandalism of its visitors from the upper world.

The Slouper Cave is at least 1,422 feet long. Viewed as a whole, it makes an unpleasant impression upon the spectator, but there are certain parts of it which have a grandeur of their own, such as the so-called king's fortress. The great hall with its deep abyss, its stretch of cascades with their stalactite adornment, and the small lake in its lowest depth, towards which the visitor can descend to a distance of 342 feet, are all interesting. The sight of the vast space filled with a chaos of colossal rocky ruins, with chimney-like openings, blocks of travertine piled and heaped up like subterranean icebergs, and the deep night of the hidden background, from which the roar of invisible waters is heard, is not without a sullen grandeur, and may well have filled honest Nagel with affright. The *débris* is massed together or scattered abroad in the wildest confusion, rising in solitary mountain peaks, or lying like giants overthrown on the bed of the cave. Torn blocks of pit clay, layers of grey stone, forming a conglomerate mass with bones and fragments of travertine, everywhere meet the eye; and the presence of the travertine, which has come from some unexplored recesses, seems to indicate that there are other and unknown caverns yet to be discovered between the upper and lower vaults of the cave.

The floor of the cave is covered with a layer of travertine which occasionally rises up in stalagmites, upon which those blind denizens of underground caves, the swift *scyphus spelaeus* and the lazy *leabonum troglodytes*, have taken up their abode. In some places the formation of travertine, favoured by special circumstances, is very great, and has preserved the bones of prehistoric animals from the influence of the weather and the wild attack of the waters.

A well-known and beautiful cavern is the Igritz Cave, in Biharer Komitate in Hungary. It consists of a number of small and large halls connected together by many passages. Many of these passages seem like artificial vaults and cellars. In one place a very narrow passage leads to the so-called bear's den, the largest and finest part of the cave. This chamber has the appearance of an almost circular hall, whose walls meet in the centre, and form a vaulted roof with several little niches which have been gradually formed by the erosion of the water. The diameter of the hall is from seventeen to twenty-six yards, and its height thirty yards. The floor is covered with yellow clay, which is found in great abundance in the neighbourhood, and buried in the clay to a depth of several feet are bones of extinct bears and hyenas.

Among the caverns of England, the best known are the caves near Torquay, the Peak in Derbyshire, the Kirkdale caves and others in Yorkshire, Poole's cave, near Buxton, and several others. The cave of Dalsteen in the Hebrides is said to extend below the sea toward Scotland. Some visitors who penetrated far into the interior in the year 1750 declare that they heard the rushing of the sea above their heads, and that the fall of a stone which they let fall into a ravine was heard for more than a minute. Both these statements are exaggerations.



WYER'S CAVE.

Countless grottoes of a similar character exist in other parts of the earth but their fame is confined to their own neighbourhood. Among the most interesting are the desolate caves of Wonderfountain in the Transvaal, a system of underground passages, whose extent has never been ascertained. The Maoibach river flows through them for eighteen miles underground.

The most celebrated cavern of America is the famous Mammoth Cave in Kentucky, U.S. Its size far surpasses all European caves, and even its ante-chambers and passages are as large as most of the known caverns of the old world. Many of these side chambers have never been trodden by the foot of man, so that the extent of the giant cave as a whole is a matter of conjecture. It has been estimated, however, after careful calculations, to be 150 miles long.

The name, Mammoth Cave, has sometimes led to the belief that bones of the mammoth have been found within it, but it is more probable that the name originated from a colossal block of stone found in one part of the cave, and called the mammoth, from its supposed likeness to that extinct animal.

Long after the country was colonised by Europeans, the cave escaped their attention. It was discovered in 1809, by a negro, who entered it in pursuit of a bear, but little store was set by his discovery. In the years 1812 to 1814, several negroes were employed within it to extract saltpetre; but the enterprise not being lucrative, it was abandoned, and the cave was again forgotten. With the gradual spread of education, the interest in the cavern revived, and the number of its visitors increased. Most of them ventured in for a little distance, and then returned, without having gained any idea of the extent of the interior. It was not until one adventurous explorer, more daring than the rest, ventured farther than his companions, and did not return, that a more thorough search was instituted. The report that a man was lost in the labyrinthine corridors of the cave was quickly spread, and a general exploring expedition was set on foot. In two days the missing stranger was discovered and brought out in safety, and the reputation of the cavern was established.

The fame of its wild and terrible scenery penetrated far and wide ; and in face of its subterranean terrors, a large and handsome hotel was at once erected, with every convenience to smooth the traveller's path. A railway carries him near to the spot, and the rest of the distance is easily traversed in a carriage. Excursions are arranged, conducted by experienced guides, starting at half-past nine in the morning, and the visitor who misses that hour is forced to postpone his visit till the following day.

Preceded by the guide, and armed against the wonders of the lower world, with stores of eatables and drinkables, the procession of visitors sets out toward the entrance of the cave, which is generally veiled in mist. The mist is caused by the moisture of the air which is condensed by the low temperature of the air in the passages underground. The atmospheric heat within the cave is very constant, and amounts to 86° Fahr.

The air underground is exquisitely pure, and quite free from ammonia; the amount of carbonic acid it contains is rather less than that of the outer air. As soon as its properties were recognised and announced to the public, American enterprise rose at once to the occasion, and established a hospital for consumptive patients within the cave.

After a short pilgrimage through the interior a wide space is reached, called the Rotunda, one hundred feet high and one hundred and eighty in diameter. Then the path goes by steep precipitous rocks to the Methodist Chapel, a grotto fifty feet high and eighty wide, where Methodist services were held soon after the opening of the cave. In this cave the visitor meets with the first spring of water, which pours itself into a deep basin. Then comes the great arch which spans a hall sixty feet wide and fifty high, adorned with the most wild and beautiful stalactitic formations. A block of stone forty feet long, twenty-two high, and ten wide, shaped like a sarcophagus, stands in the centre, and is called the giant's coffin. Near it lies the stone mammoth, which, the imagination aiding, looks like the old-world animal resting in his den, and to which the cavern owes its name. The passage now becomes very low and narrow, so that the visitor is obliged to stoop down at times, and can only advance in single file. When several lofty halls have been passed through, the bottomless pit is reached, a chasm two hundred feet deep, where until of late years the exploring party were obliged reluctantly to turn back. With much expenditure of skill and trouble, the chasm has now been bridged over, and affords access to the distant and most beautiful parts of the cave.

When the bridge is crossed, the visitors arrive at the Dead Sea, a clear pool, fifteen feet deep, fifty long, and twenty-two wide. This leads on to the River Styx, whose presence has already been announced by the rushing of a waterfall. A natural rocky bridge drawn across the streams forms the boat by means of which the waters of Lethe are crossed. The walking now becomes very difficult, and the path is not unaptly called Purgatory. It leads hrough a gloomy cavern to the dark waters of the Echo River. This gloomy lood is crossed in a boat, but the entrance is so low that the traveller has lways to stoop down, and when the water is high it is impossible to cross it, or the underground rivers of the Mammoth Cave have their times of high nd low water, like the rivers of the upper world. They are closely connected vith Green River, and rise and fall with the rise and fall of its waters. This onnection is shown in a wonderful way by the occasional appearance of eavy mists above the Echo River. When the waves of Green River are varmer than the air of the grotto through which it flows, the watery vapours re condensed, and appear as impenetrable fog.

The path again becomes difficult, but leads at last into the Waterfall Chamber, a vast hall formed of wild jagged rocks, from which countless arrow streams rush down and disappear within a funnel-shaped opening in he ground. A street some 2,733 feet long, adorned in many places by groups f stalactites, leads to Ole Bull's Concert Room, a hall where the Norwegian iolinist once played during his visit to the caves. Next comes Rhoda's Arcade, famous for its numerous lime and gypsum crystals. The arcade eads to Lucy's Hall, a vaulted chamber three hundred feet high, whose walls re covered with immense stalactites of beautiful form and endless variety. This hall is the largest chamber of the Mammoth Cave which has as yet been xplored.

Having followed the road through a long rocky labyrinth, the traveller inds himself before a steep ladder, which leads through a little hole into an pen space, generally used as a halting place for the visitors and guides. After a rest, a beautiful corridor hung with wonderful crystals is crossed, and he Snowball Chamber reached, where the roof looks as if it were made of othing but snowballs gummed together. Many of them have fallen to the round, but their place is supplied by new formations. Near the Snowball Chamber is Cleveland's Cabinet, a large but not very high room, where the talactites are so beautiful that the visitor is reminded of a flower show. Farther on the cavern opens into the so-called Rocky Mountains, a wild, lesolate region, which must be traversed with great care and no little lifficulty. Here the visitor reaches the end of the journey, for the adjoining aves and labyrinthine passages have never been explored; but, as if the last mpression made upon him were not to lose in strength, a grand and awful ight awaits him. This is the so-called Maelstrom, a terrible abyss, twenty eet wide and two hundred deep, from which a dull roaring sound is heard ar below. On approaching cautiously to the brink, vivid Bengal fires are ighted and held above the mouth of the chasm. Many have stood looking lown into the depths, but no one seemed inclined to explore its recesses. Six hundred dollars were offered to any guide who would make the attempt, ut the boldest shrank back from the task. In the year 1859, however, a oung hunter from Louisville, named Prentice, who had visited the caves ccompanied by some scientific men, offered to venture on the descent. He ound a waterfall and several chambers in the side of the chasm, but had a arrow escape from death on being drawn up to the surface; so that up to the resent time no one has attempted to repeat the experiment. The caverns re of special interest to the geologist, because, being imbedded in clay or overed with incrustations of limestone as hard as stone, they have preserved he remains of their former inhabitants, and lay bare the mysteries of remote ges to the gaze of the present. The student who carefully questions the ontents of the vast cave, passes successively through more and more distant epochs, and before his eyes unroll vast pictures of prehistoric life lost to song and saga, but treasured in the faithful silence of the rocks.

While on this subject we will say a few words of the curious discoveries made in Victoria Cave, at Settle, in Yorkshire. The cave was discovered by accident in the year 1838; and in the interior, lying very near the surface, were found Roman urns and coins of the time of Trajan and Constantine, showing that the cave was inhabited in the third century of our epoch. Numerous bones found in the same place were submitted to scientific inspection, and pronounced to belong to oxen, which formed the principal food of the inhabitants. Bones of goats, pigs, and horses, and more rarely, of stags and deer, were also found. It is probable that the earlier dwellers in the cave were shepherds. Ornaments of various kinds, particularly glass beads and bone hooks, were found, and known to belong to the fifth century. The presence of these objects in the cave is very remarkable, and seems to show that it must have formed the hiding place of people accustomed to a certain degree of luxury, who escaped with their valuables from some threatened danger. And history tells us that after the withdrawal of the Roman legions at the beginning of the fifth century, the Britons fled for refuge to the caverns of their mountains from the attacks of the Picts and Scots, before they formed in mass to drive back the invaders. But long before the Britons dwelt within the Victoria Cave, it had been the home of human beings; for at a depth of two yards below the layer where the buried remains of civilization were discovered, there were found imbedded in the hard greyish clay, harpoons of bone, three flint stones, bone ornaments, and the broken skeletons of brown bears, royal stags, horses, and oxen. The *débris* lying above the stratum containing the relics of Roman civilization was twenty-seven inches deep, and represents a period of 1,200 years; so that if that be taken as a standard of measurement, the lower stratum must point back to a date of nearly 5,000 years. Below this stratum is a layer of tough grey clay; below that, at the entrance of the cave, at a depth of about sixteen yards, a layer of reddish grey clayey soil rests upon a substratum of limestone, whose massive blocks were filled up by clay and sand. In the pit clay were found the remains of hyenas, long-haired rhinoceros, mammoth, and bears together with human remains in the same state of petrifaction.

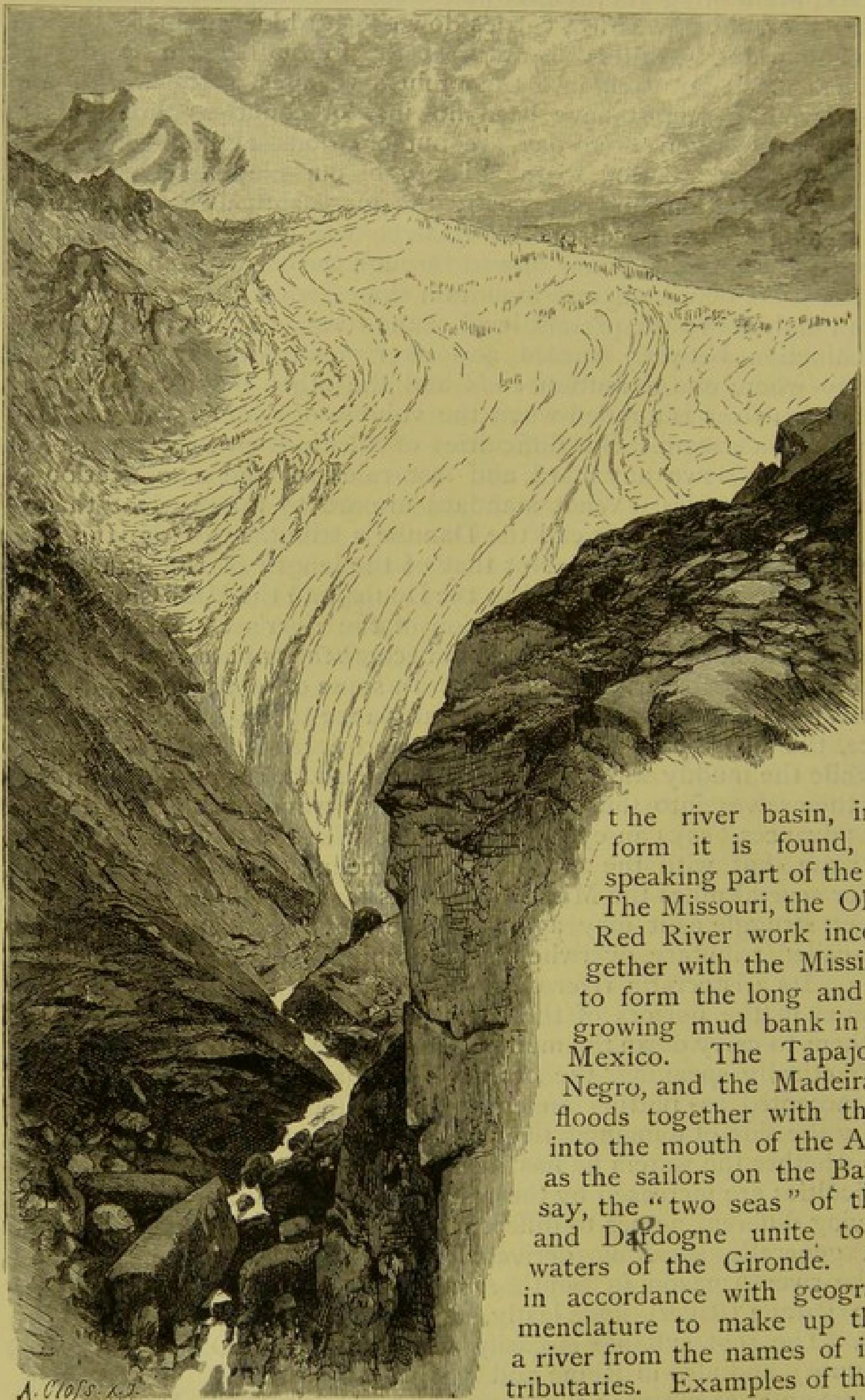
How long a period of time has passed away since the cave has been the home of hyenas, while the long-haired rhinoceros roamed through the neighbouring forests, we do not know. But the epoch lies so far behind the present time, that since England was broken off from the mainland, the severity of the winters has greatly decreased, and man has risen from the condition of a savage clothed in skins, and armed with bow and arrows, fighting for very life against the giant beasts of the old world, to his present state of culture and civilization.

RIVERS.

The running water which has its source in the springs, and then flows through the land as streamlet, brook, and river, has been in every age the connecting link which joins people to people and land to land. To-day, just as it was a thousand years ago, any one who wishes to make his way into unknown territories looks upon the river as his great high road; and wherever they have once existed, these high roads appear to defy the attacks of time, and to outlast the life of nations. Unresting, unhindered, brook, stream, and river hasten to the sea; thousands of years pass by, and do not dry up the parent spring, or exhaust the silver thread as it rushes downward from the rock. The rivers, round whose banks still linger the earliest memories of our race, are flowing yet: Tigris and Euphrates still rush to find the Persian Gulf; the Nile, unwearied, carries down its turbid waters to the sea, and the Castalian spring still wells forth at the foot of Mount Parnassus. Nay, the rivers reach far back into the prehistoric ages of the world, and some of them, we know, must have been flowing for countless thousands of years. And yet our rivers of to-day are but creations of yesterday, when viewed in chronological relation to the history of our planet. They belong to its youngest formation, and are partly the mere shrivelled remnants of former and far mightier predecessors. We can sometimes form an idea of the mighty masses of water which once flowed through the earth, when we see the *débris* they have left deposited, and mountain slopes widely distant one from the other, and high above the present level of the river.

The distinction between stream and river is an arbitrary one; it is difficult to say where one definition ends and the other begins. Generally speaking, the term river is applied when the volume of water is greater than that which we call a stream. But difficulties of all kinds present themselves when we try to lay down any hard and fast rules for the classification of rivers and their tributaries. What standard are we to take? Not that of the volume of water, or we must call the Danube a tributary of the Inn, and the Rhine a tributary of the Aar. Not that of the length of the stream, for then the Rhone must be subordinated to the Doubs, and the Mississippi to the Missouri. Not that of unchanged direction of the river's course when two streams meet together, or the Danube would become the tributary of the Drau, and the two together tributaries of the Sau. In some cases the appellation of "principal river" is proved by the most casual glance to be utterly incorrect. For instance, the Mississippi is seen flowing northward a few miles above St. Louis, while the muddy waters of the larger Missouri, rushing up from the west, pour themselves into the green transparent waves almost at a right angle. "It advances," says an eye-witness, "not with the modest influx of a tributary stream, but with the crushing, overwhelming flank attack of an enemy." For several miles the Mississippi fights for an emerald purity of its river life; but, struggle as it may against the torrents of mountain mud with which its so-called tributary overwhelms it, nothing remains of its existence but its name. Its aristocratic river deities are vanquished and driven out of sight, whelmed in the horrors of the muddy giant which seizes upon them, and forces them to carry down the mud of the Rocky Mountains to the Gulf of Mexico. Practically speaking, the ordinary language of our geographies is everywhere accepted as putting an end to the difficulty; but in unknown lands, and by the side of unnamed rivers, the explorer must often be left in doubt as to whether the waters he has discovered are principal or tributary; and the difficulties are increased by the custom, so prevalent among uncivilised tribes, of giving different names to different parts of the same stream. These names are, generally speaking, derived from some root meaning water or stream. The river Amazon, in South America, is called Parana-acu (Great River), then Parana (River), and, lastly, Parana-hyba (River which imitates the Parana). The root syllable is easily distinguished in Dan, Daultz, and Donau (Danube), and also in Rhine and Rhone.

The question as to whether the river which gives its name to the system is really the most important by its position, course, and volume, is of very little practical purport. In reality a river is nothing but the collected waters of all the tributary brooks, streams, and streamlets which flow into it along the whole extent of the basin. It comprises within itself the million tiny rills which trickle from the glacier rifts or fissures of the rocks. It continually renews itself, and all its tributaries share in its renovation. The drops of rain and melted snow filter into it through the porous banks, and indeed the whole mass of water in the river basin, in whatever form it is found, is strictly speaking part of the river itself. The Missouri, the Ohio, and the Red River work incessantly together with the Mississippi itself to form the long and constantly growing mud bank in the Gulf of Mexico. The Tapajoz, or Rio Negro, and the Madeira, roll their floods together with the Solimoes into the mouth of the Amazon, and as the sailors on the Bay of Biscay say, the "two seas" of the Garonne and Dordogne unite to form the waters of the Gironde. It is quite in accordance with geographical nomenclature to make up the name of a river from the names of its principal tributaries. Examples of this are found in the Somme-Soude, and the mountain streams of the Gyrond (Gye and Onde), in the Upper Alps, and above all the Virginian river Mattapony (Mat, ta, po, ny).

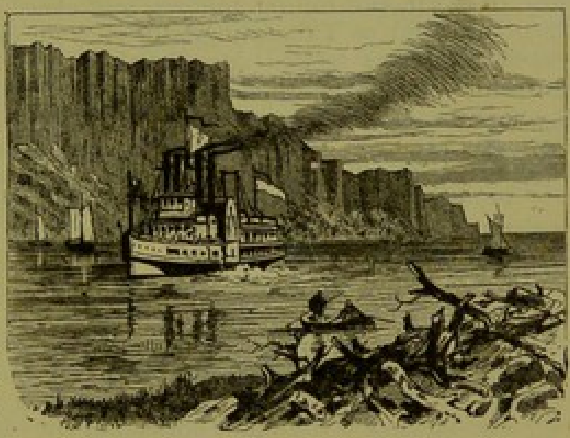


SOURCE OF THE RHINE.

EFFECTS OF A HURRICANE.

Development and Volume of Rivers.

Rivers are generally divided into three classes, according to their different characteristics. Ocean rivers are those which empty themselves directly into the ocean. Inland rivers those which cannot directly reach the sea, such as the rivers of the steppes, which either flow into lakes which have no outlet, or are choked by the sand or dried by heat. Coast rivers are those which rise at a short distance from the sea, and reach it by a direct course. No rivers, however, flow in the shortest line from the source to the mouth; on the contrary, they delight in winding curves which are the delight of the landscape painter, and sometimes in capricious loops which are the despair of the boatman. In this latter respect the Moselle is especially famous, for it is only too possible that the boatman may find himself at the end of a long day's sail in front of the very inn from which he started in the morning. In some cases it happens that two different river systems are connected together by a natural channel, so that the waters of one and the same river flow in diametrically opposite directions. This bifurcation is found on a small scale in many European rivers, but the best example of it is seen in the Orinoco, from which one powerful side stream, the Cassiquiare, turns aside in the upper part of its course, and empties itself into the Rio Negro. The shorter the way taken by the principal bulk of the river from spring to mouth, the greater is the force of its current. Every river forms with its tributaries and sub-tributaries a watery network which intersects the land in every direction, and the whole surface so intersected is called the river basin. Its extent may be approximately determined by drawing an imaginary straight line between the springs of all the tributaries. The surface extent varies of course greatly, according to the length of the principal river. The largest river basin in the world is that of the river Amazon, which embraces 2,000,000 square miles. The Mississippi basin is about half that size. These calculations must necessarily be taken to express the nearest round number to the exact extent, as it is impossible to be strictly accurate to a square mile or so: the shorter the river, and the better known the neighbourhood through which it flows, the more accurate will be the estimate of the extent of the river basin, and it is the same thing with the length of the river's course. In this respect we have no trustworthy data on which to base our calculations, even when it is a question of European rivers. For instance, the Volga is said by some to be 2,100, and by others 2,400 miles long. The length of the Rhine is sometimes given as 700, and sometimes as 800 miles, that of the Rhone as 500 to 645, and even that of such a short and important river as the Thames offers no exception to the general uncertainty and difference of opinion.



Scenery on the Hudson River.

When we find that the length of the Amazon is sometimes given as 3,150, and sometimes as 4,000 miles, the Lena at 1,800 and 2,700, and the Yang-tse-Kiang at 3,000 and 3,570, we need not wonder that the question which is the longest river in the world remains unanswered. If the Missouri is considered to be the principal stream of the Mississippi system, the choice seems to lie between it and the Nile, unless indeed the Yang-tse-Kiang be allowed to enter the lists as a third competitor. But if, instead of the length, we consider the volume of the great rivers, everything is changed. The volume of a river is by no means decided by its length, but depends principally upon the rainfall of the surrounding district. Thus we find, for example, that the Mississippi, with a river basin of twice the size, does not carry down to the sea a third part of the waters of the Congo. The last-mentioned river flows for the greater part of its course through the regions of tropical rains. But the Congo itself, although nearest in its wealth of waters to the Amazon, is yet surpassed by one-third of the volume of its magnificent rival. No other river in the world approaches this mighty stream, which, it is said, carries down to the sea a fourth part of the fresh waters of the globe.

Avé-Lallemant has given a graphic description of the Amazon, from which we may gain some idea of its extent and grandeur. The Amazon, he tells us, appears as a great world-river, or fresh-water lake. The united mouths of the Gran Para and the Amazon are truly vast in their proportions; the former, where the Tocantins falls into it, and receives the name of Gran Para, forms a fresh-water lake of such extent that it participates in the ebb and flow, in storm and rolling billows, and every characteristic of the open sea. In navigating the river as far as Tabatatinga, the view on every side is bounded by sea and sky, an horizon which is always looked upon as the very sign of boundless immensity. And when this horizon is recognized upon an inland lake, its wonder and grandeur are still more impressive; the vast mass of waters reaching out before the eye, so that the curved form of the globe is distinctly seen. This lake extends for hundreds of miles, the long, wide, powerful current of the river-tide flowing in constant change from west to east.

Where the great waters make a sharp curve, or are broken up by islands, they appear in their true character as a river; glimpses of distant wooded glades, and the faint blue of mountain ranges appear and disappear upon its banks, parted by miles of intervening waters. And between the separate islands flow quiet branches of the stream, sought out by sailors, and called by the name Parana (river). It is strange to come round some sudden woodland curve, and find that the peaceful river is left behind, and the ship is once more confronted by the "Great Stream," presenting every well-known sign of the open sea, whether the voyage is made eastward with the rolling current, or battling against it toward the western shore.

The scenery of the water horizon at the mouth of many of the tributaries is very fine when the traveller sails out of the tributary into the principal stream. The mouth of the tributary is seen from a great distance long before it is reached; and looking straight beyond it, the Amazon itself is seen with no boundary but the encircling sky line. At Tapajoz the "beautiful wide stream," which is, however, only a fifth or sixth rank tributary, this grouping of the water is singularly beautiful. The traveller sailing along the northern shore of the Amazon, and crossing thence to Tapajoz, looks to the south down the Tapajoz, and there, as well as to the east and west of the Amazon, is water horizon only. Involuntarily one is reminded of similar scenes in the north, when among the Danish islands the sailor looks before him along an arm of the Baltic Sea.

Perhaps this resemblance to the open sea is still more striking when the Amazon is entered from the dark waters of the Rio Negro or Rio de Madeira. Clear and free from the vast masses of floating timber, these rivers seem to pour with very wantonness of power into the principal current; for awhile the dark waters of the tributaries, sharply contrasting with those of the principal stream, flow together in the same channel as the Paranaacu, which does not seem to have grown larger from their influx. And yet the Rio Negro is 1,350 miles long, and is made up of many noble tributaries, and the Rio de Madeira, 2,250 miles long, carries with it no less important streams. And the imposing phenomenon of a water horizon round a river or fresh-water lake is seen at Paulo Olivença, where the stream has yet nearly 2,300 miles to run to the sea.

The Congo was always known to be one of the most important rivers of the world, and has lately been more accurately and closely examined. It has hollowed out for its enormous volume of waters a narrow bed of very various depths. In many places of the estuary no bottom was found at a depth of 1,200 feet, and its waters penetrate for forty miles into the sea, and yet retain their fresh taste unmixed with salt. The course of the great current is distinctly traced by the floating masses of bamboos carried down its surface far out into the sea. The swiftness of the current is estimated at from four to eight miles an hour. The Congo current is perceptible at a great distance seaward, and ships are obliged to take account of it. It is said that as far as 300 miles out at sea the yellowish green of the river water and the course of the current are distinctly recognised.

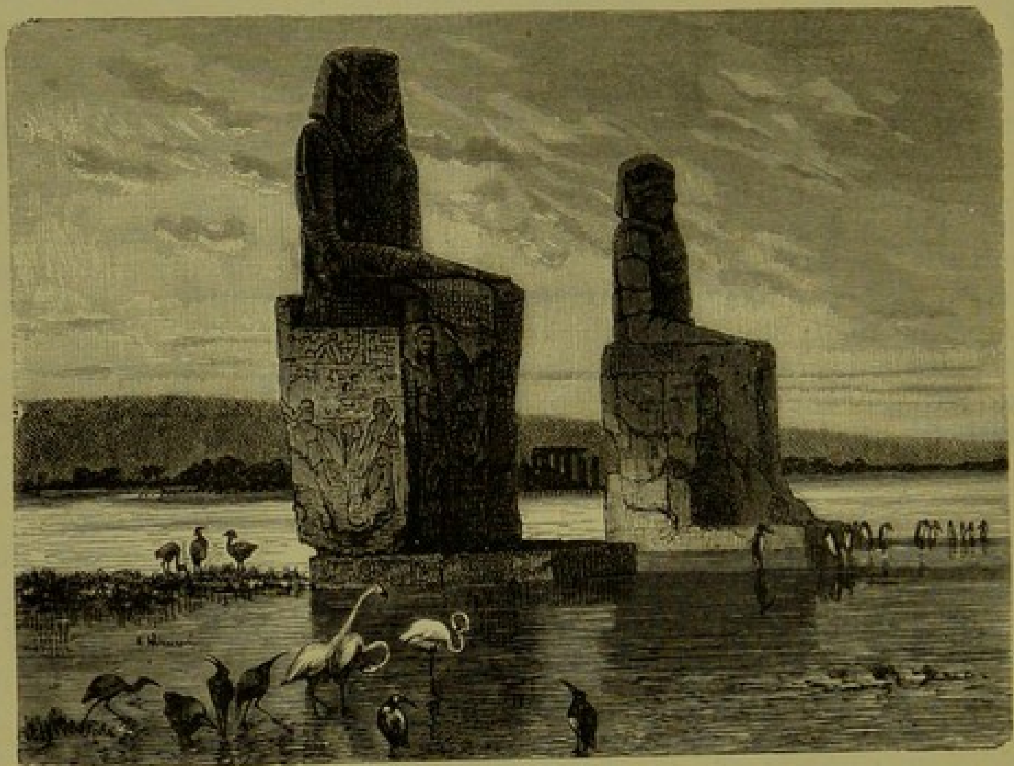
Above the falls, where the river breaks through the rocky mountains of the coast, the river is from two to four miles wide, with an unbroken surface, and a speed of two to three miles an hour, and it is said to carry down at low water 2,080,000 cubic feet a second.

Of course it is impossible, when speaking of these giant streams, whose high-water mark varies greatly in the course of the year, to institute accurate average measurements. The student has to be contented with statements and guesses which may occasionally be far removed from the truth. Thus it is said that the Amazon carries down to the sea 104,000 cubic yards of water a second. But according to Lallemant's calculation it carries into the Atlantic at high water 325,000 cubic yards a second. The average volume of water of the Congo amounts to about 70,200 cubic yards a second. Next in size to the Congo comes the Yang-tse-Kiang, or "Sau of the Ocean," which, as the Chinamen say, flows on "bottomless like the sea." No accurate account of its volume has been given as yet. Another giant stream, the Mississippi, has, on the other hand, been carefully studied, especially with reference to its waterfalls. It is said to carry down 11,060 cubic yards at low water, and an average of 29,900 cubic yards a second. The Nile at Esneh, according to Jordan's average, carries down 11,050 cubic yards a second. The minimum from March to June is 4,160, the maximum in September is 26,260 cubic yards. The Ganges has an equally great volume of water, and the Brahmaputra an average flow of 14,300 cubic yards a second. On comparing these statistics with those given respecting our English rivers, we find that the average volume of the Danube amounts to 11,700 cubic yards a second; that of the Rhine to 2,600, the Rhone and the Po about the same, and the Loire and the Seine to 690.

Periodical Rise and Inundation of Rivers.

As we have stated in an earlier chapter, many rivers are subject to periodical risings in the course of the year. These risings are dependent on the rainfall of the river basin. When, as in tropical regions, the rain falls at certain well-defined seasons of the year, the rising of the rivers occurs with wonderful regularity. The rainy season of the tropics corresponds to the time of the solstices, so that in the hot countries to the north of the equator it happens in our summer, and for the southern lands in our winter. When the time at which a river periodically rises is once learnt, it is easy to determine the situation of the springs. It was in this way that, even before Stanley's explorations, the Lualaba, discovered by Livingstone, in which high water occurs in winter, was known to be connected with the Congo, instead of flowing into the Benue or the Nile.

Among the rivers subject to periodic rise, the Nile takes first rank, and attracted the notice of the ancients. To its regular and periodic inundation Egypt owes its fertility, and from a dusty plain becomes first a fresh-water lake, and then a flower-bed. A high-water mark of twenty feet is not enough; twenty-three gives good promise of a rich harvest, and twenty-six brings an overplus. The ancients vainly busied themselves to fathom the mysterious causes of the inundations of the Nile; they could do no more than form guesses. To this day the night between the 16th and 17th of June is set down in the Coptic Calendar as the "night of the drop," in honour of the old legend, according to which a drop falls from heaven, and causes the Nile to rise. A fortnight later the flood is noticed through the length and breadth of the land, and reaches its maximum towards the latter end of September. At that time the towns and villages lie scattered upon the surface of the yellow turbid flood. To turn its life-giving waters to the best advantage, the fields and plains are divided into separate basins, into which the Nile water can be carried. In the beginning of September the dams are broken through; the sowing begins in October, while the waters of the river gradually sink till June. One of the two sources of the Nile, the eastern or White Nile, comes from two great lakes situated near the equator. These great basins form the receptacle of all the rain which falls in those regions almost incessantly for ten months of the year, and render it possible for the Nile to carry through its long course across parching desert wastes four times the volume of water carried down by the Rhine; but they are *not* the source to which Egypt owes its fertility. The lake sources of central Africa, we are told, create a stream



INUNDATION OF THE NILE.

which has at all times a sufficient quantity of water to resist the influences of filtering and evaporation. But if the Nile received no other aid, it could never overflow its banks; and Egypt, deprived of its yearly inundation, would have to struggle for bare life, and restrict its agricultural operations to the banks of the river. The inundation is exclusively due to tributaries which flow into it from Abyssinia—the two great Abyssinian streams of the Blue Nile and the Atbara. These rivers, which are of immense size in the rainy season, shrink and dwindle into utter insignificance in times of drought. The Blue Nile becomes so shallow that it is scarcely navigable, and the Atbara runs completely dry.

In the rainy months, which last from June to September, when the sluices of heaven open over the Alps and forests of Abyssinia, the Blue Nile and the Atbara carry away the waters which fertilise the barren fields of Egypt.

While the Nile is the only stream which carries away the rainfall through the vast plains of equatorial Africa, it may be looked upon as a gigantic hydrometer. When the river is high, it is evident that more rain has fallen than when its waters are low. The water-mark was highest (thirty feet) in the days of Emperor Claudius, and the lowest (eight feet) just before the assassination of Pompey. Careful examinations have shown that at least in the years 1825 to 1872 the high-water-mark was subject to a tolerably regular alternation; the minimum occurring in 1835, 1845, 1857, and 1866; and the maximum in 1828, 1841, 1849, 1861, and 1870.

The rivers on the outskirts of the desert of Sahara are only at periodical intervals of any noticeable size and importance. As soon as the rainy season begins, the mountain streams rise wildly, tearing down with them rocks and rubble from the heights, and hollow out the channels or *wadies*, which, when the rains are over, remain dry and empty for the rest of the year. The sudden rise and disappearance of these mountain streams has been graphically described. In the bay of the sea on which Kosseir is situated, opens a wide and hollow channel, which gives passage to a stream rising in the mountains about four and a half miles off, and flowing through a desolate region destitute of all vegetation. In the winter time it is transformed into a tumultuous stream, which overflows the country round. When the rain descends upon the mountains, it swells and developes so suddenly, that the inhabitants have scarcely time to escape and save their property and lives. In December of the year 1864, when no rain had fallen in Kosseir, the stream suddenly poured down from the heights above into the valley. Immediately the whole population of Kosseir—men, women, and children—ran out in the dead of night to see the wonderful sight of the fresh running water, to collect the precious liquid, and save it from being wasted, and even to bathe in its streams. On the following day all the camels, asses, and porters, both men and women, were busily employed in laying up stores of water for the days to come. In two or three days nothing remained but a few hollows filled with water, and even this was soon flavoured with salt.

Far grander than the inundations of the Nile are those of the river Amazon. The low-water season of this great river lasts from June to November, and then its level gradually rises, and towards the end of May reaches a height of sixty-six yards. Its waves now roll into its remotest wood-fringed bays, the tributaries for miles above their mouth form lakes rather than rivers. Forest and river-life are then so closely connected, that the animal life they contain tends toward a species of amphibious character, whether the creatures affected belong to land or water. Similar circumstances have been noticed upon the plains through which the Aranca, Apure, and Payara rivers flow. The Brazilian river, San Francisco, sometimes extends for miles beyond its banks, so that the boats leave the regular course of the river, and take the shortest way across hedge and field, miles away, it may be, from the real coast, at the risk of suffering shipwreck upon some hill, which at another time may be the pasture land of cattle.

The extraordinary variations of the high-water line of the Amazon not only change the appearance of the river itself, but greatly influence the form and aspect of the banks. At whatever level the river may flow, its banks are always in danger of being dragged down into its swelling floods; they are safest, however, when the river has reached high-water mark, for then the pressure against the steep walls of loam, with their heavy load of woodland and giant trees, is so strong that they are kept upright even when on the point of giving way. But when the pressure is relaxed, and the high slopes, filtered through in every direction by trickling streams, are left to themselves, while the treacherous flood undermines them from below, a whole stretch of land may fall at any moment from its own weight or from any slight impetus given to it from without. The fall of a tree, the stroke of an oar, suffices at times to bring the overhanging mass toppling down into the stream, dragging after it great slopes of woodland, while the water driven back by its fall returns with redoubled force to complete the work of destruction. The boatmen, when deserted by the east wind, and obliged to propel their boat by the slow process of punting, or to make their way up stream by the help of ropes, glide by these dreaded, overhanging slopes with the greatest caution; even the steamers avoid them, lest the mere churning of the water by the paddle wheels should give the last shock needed to bring down the mass of earth upon their vessel. In the last century a governor and his suite, sailing up the Rio de Janeiro in several vessels, were lost by the fall of one of these overhanging slopes; and a few years since such a large tract of the bank fell over into a smaller river in Peru, which also falls into the Amazon, that the whole bed was choked by it; the waters dammed up into a lake, giving a death-blow to the cultivation of the country, and changed the appearance of the whole neighbourhood. And although this work of destruction is not carried on daily, on such a gigantic scale as in the instances we have just described; yet the eye everywhere meets with hanging gardens, and woodland scenery floating in the air in the wildest confusion, slender palm stems sixty or eighty feet high stretching out over the water like immense fishing rods, ending in feather tassels waving above the surface, and slowly descending, till the flowing stream seizes upon the ends of the leaves, and drags them down, bringing in their train a considerable tract of land.

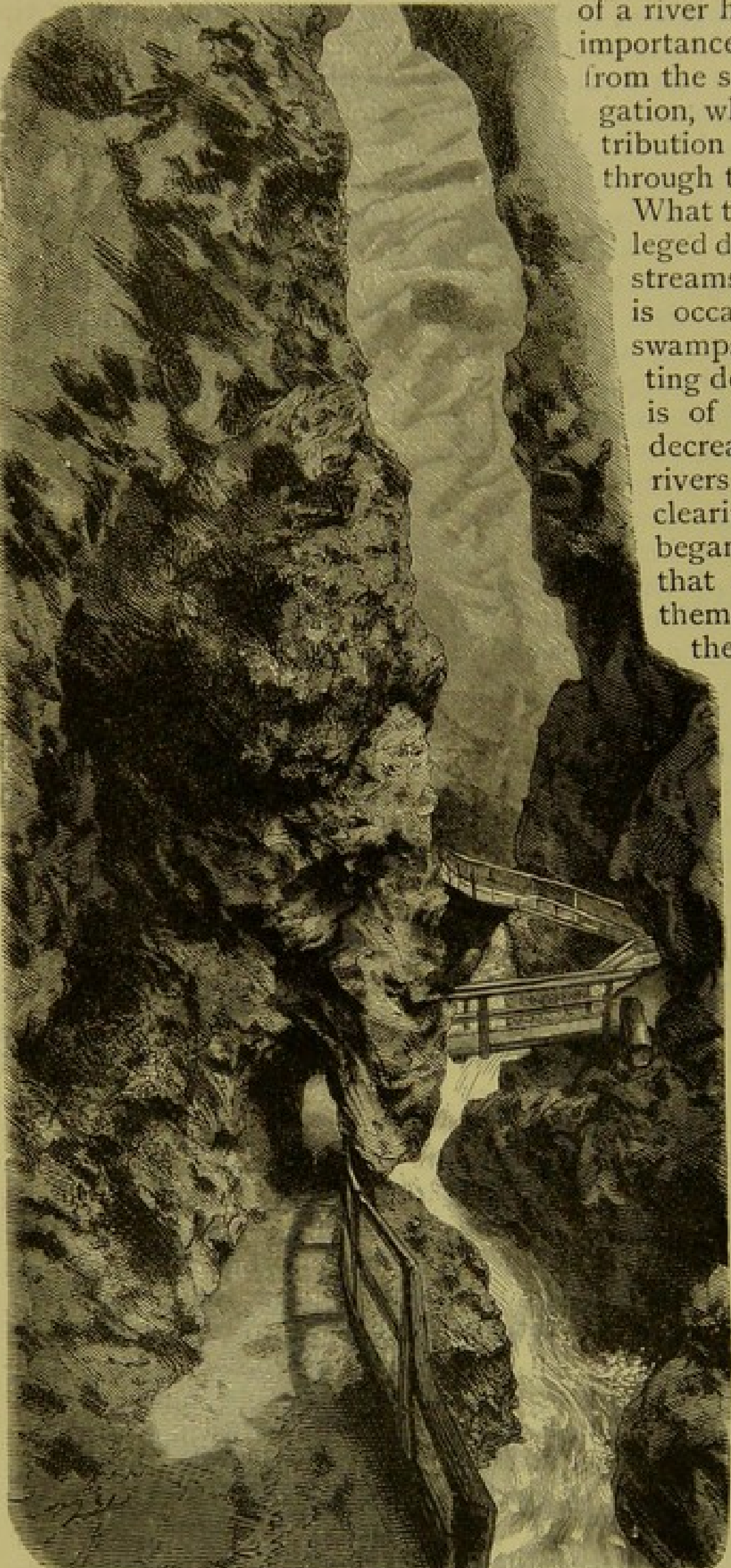
If the tree stems are not too massive, they begin, as soon as they have been despoiled of their crown of leaves and smaller branches, to set out upon their long journey to the ocean, some of them reaching their destination in safety, and some checked and stranded upon a curve of the shore, an island, or a sandbank. In long chains, extending at times for miles in almost uninterrupted succession, the pale-grey mummies of fallen forest trunks, piled one upon another in chaotic confusion, float like a moveable shore beside the river's bank—one of the most unique characteristics of the Amazon river scenery. Sometimes they lie piled like a rampart before the bank, where they often form a good landing stage for a little settlement, and are also useful as a protection against floods. But should some great tree lie stranded in mid-stream on a shallow or sandbank, it gradually catches other trunks, floating grasses, bushes torn up by the roots, anything, in short, which comes within its reach, and forms a temporary island, which, when the water rises, is uplifted from its anchorage, and, like the fabled island where Apollo was born, drifts with the stream along its wild fantastic course. Seen from a distance, these tangled masses of floating islands present the strangest aspect, and remind the traveller of the cloud castles of Fata Morgana. The water horizons of the Amazon have also the peculiarity of rendering visible above the horizon, and as if floating in the air, objects which in reality have not yet come into sight; and the two banks which enclose the horizon appear raised above it and wider apart than they actually are. The driftwood and island masses, above described, seen from a great distance, appear floating in the air, and do not assume their proper position until they have really come into sight above the horizon.

The rise of the waters at the mouth of the Mississippi takes place at the beginning of December, and the river reaches its maximum height in the middle of January. Then it falls, and does not rise again till April, when it gradually increases for the next two months, and generally overflows its banks in June. It flows for hundreds of miles through artificial dams, and at the times of the highest floods the steamers are often on a level with the tops of the houses. Only too often these dams are torn open like a sheet of paper, and the land beyond them inundated for miles; plantations destroyed, houses and settlements washed away, and forests uprooted; and all this ravage is wrought, not with the roar and fury of our smaller European rivers, dashing down from their mountain heights; the Mississippi is too grand and strong to put forth any visible exertion of force. Titan-like, a finger pressure is enough to break down the strongest dam; no effort, no sudden dash, is needed. Calm, slow, and majestic, the great water rises in its bed, and as calmly the strong dam gives way, without a wave rising above the even surface of the treacherous stream. But, once broken through, all hope is over for the inhabitants; no flight is possible when the Mississippi is the pursuing foe.

In Alpine streams, which have their source in the snowfields of the heights above, the melting of the ice of the glaciers greatly increases the water supply, but never causes the rivers to overflow. It is the rainfall alone which creates inundations. The Rhine, for instance, is lowest in January, and rises but very slightly in the spring. When, however, the long, continuous rains set in over the central and lower Rhine, the floods rise to such a degree that the volume of the river equals the average volume of the Ganges and the Indus. Even smaller rivers rise to an extraordinary height under the influence of these periodic floods; the Doux, the Erieux, the Ardèche are three small rivers of France, which are enclosed from source to mouth within the limits of the same department. As a general rule, these rivers flow quietly along, and only carry to the Rhone twenty-six cubic yards of water a second. On the 10th of September, 1857, they poured into their principal stream 18,200 cubic yards, more than the Ganges and the Euphrates carry to the sea. In the low-lying lands their waters rose from forty-eight to sixty feet above low-water mark, laying waste the country round, and carrying away houses and trees. The number of tree trunks carried away in one day was so great, that the Rhone was covered with them from one bank to the other, below the mouths of the Erieux and the Doux. And this inundation was exceeded by the flood of the 9th of January, 1837, when the Ardèche rose seventy-two feet above low-water mark at the bridge of Gournier.

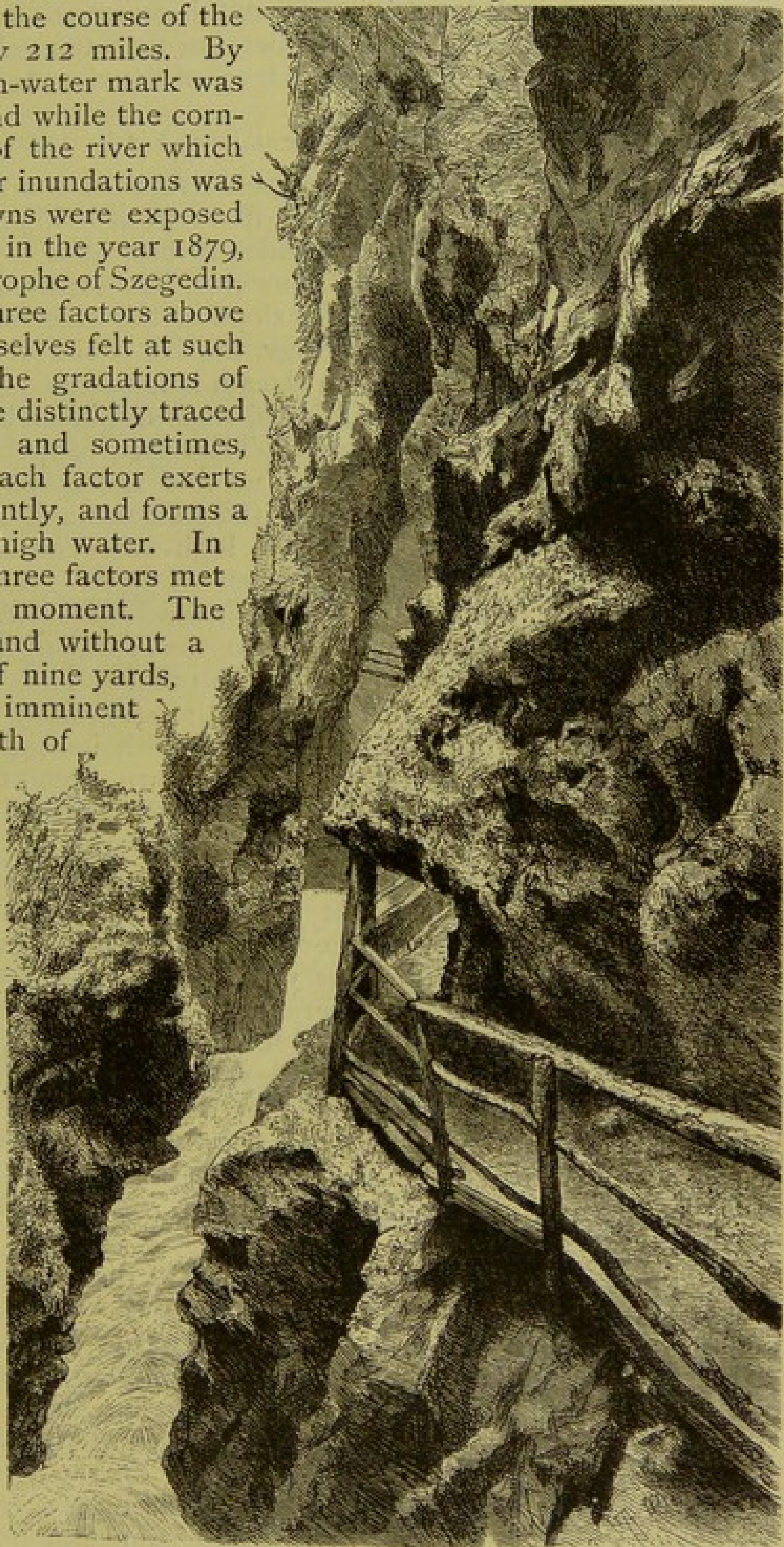
Recent investigations have shewn that floods and dangerous inundations are on the increase among the rivers flowing through the cultivated lands of central Europe; while, on the other hand, the average high-water mark gradually decreases. Our regulated, and if we may so speak, our *civilized* rivers shew a tendency, in spite of all the care and attention bestowed upon them, at the cost of many millions, to degenerate and relapse into the condition of so-called "wild waters," liable to sudden and desolating floods, and at other times dwindling away for want of water. This tendency has been particularly noticed in the Volga and the Dnieper, along whose banks clearings of forest timber has been made to such an extent that the central and lower part of the streams flow through long stretches of treeless country, and the high-water-mark is always higher than in former years. Constant complaints are made of the alterations caused in the course of the navigable parts of the stream, by the shallows made by the floods. Many channels which are parched and dry in winter and rainless summers, are changed in spring into roaring torrents that often undermine and tear away tracts of the richest ploughed land.

The same investigations shew that the average volume of the rivers remains unchanged, but this is a poor consolation; for although the average volume of a river has a scientific interest and importance, it sinks into insignificance from the standpoint of practical navigation, when compared with the distribution of the volume of water through the whole course of the year. What then is the cause of this alleged degeneration of our European streams? The answer is, that it is occasioned by the draining of swamps and morasses, and the cutting down of forest trees. Whitney is of opinion, however, that the decrease of water in our European rivers cannot be explained by the clearings made in our forests, but began at a period earlier than that in which men took upon themselves to assist and control the operations of nature.



GORGE IN SALZKAMMERGUT.

The effect of artificial control exercised over the course or volume of a river is seen most clearly in the Theisz. This muddy, sluggish stream receives almost all the water from the southern and western slopes of the Carpathian Mountains, and carries it down to the Danube. It has been shewn that three different factors are necessary to cause a rising of the river. First, the rain and melted snow of its own river basin, exclusive of the upper regions of Maros and the Szamos; secondly, the waters from the basins of the Maros, Szamos, and Save; and thirdly, the rain and melted snow throughout the higher basins of the Inn, the Danube, and the Drau. The last two of these three factors cause the Danube to rise and affect the Theisz in that way. Before the year 1845, the Theisz used to overflow the flat plain on either side, and form broad pools, lakes, and morasses, whose pestilential air reeked with fever. From that time the control or "regulation" of the Theisz began. The morass was drained, 4,800 square miles of arable land were gained, and the course of the river was shortened by 212 miles. By these measures the high-water mark was considerably raised; and while the corn-fields along that part of the river which was the scene of former inundations was now protected, the towns were exposed to danger, and at last, in the year 1879, came the terrible catastrophe of Szegedin. In several years the three factors above mentioned made themselves felt at such close intervals, that the gradations of their influence could be distinctly traced by the water-marks; and sometimes, though more rarely, each factor exerts its influence independently, and forms a separate and isolated high water. In the year 1876 all the three factors met together at the same moment. The Theisz rose rapidly and without a check to the height of nine yards, and Szegedin was in imminent danger, but on the 30th of March the river broke through the dams at Fegyvernek, above Szolnok, and poured itself into the gigantic Nagy-Sār. In the course of ten days this great discharge made itself felt at Szegedin, and the town was saved, but only for three years. The water-mark at every spring tide rises to a height of seven yards. In consequence of the wet season of 1878, the Danube rose to an extraordinary height, and dammed up the outlet of the Theisz, so that the high-water mark could only be reached at Szegedin, where the spring river tide rose along the top of the high-water level. This sealed the doom of Szegedin, and the whole valley of the Theisz, Koros, and Zagyvaer. It is of



Gorge in Salzkammergut.

no avail to attempt to guard against the recurrence of such an accident by making the dams higher, for the level of the Theisz rises with them; and, according to Van Vilovo's opinion, nothing remains but to open at the right moment the dams of the river inlets, so that the volume of water may pour itself over the land, and allow the level of the river to sink.

Upper Course of Rivers—Effect of Erosion—Waterfalls.

In large and perfectly developed rivers the course is divided into upper, middle, and lower. As the water flows from a higher to a lower level, the upper part of the course must evidently flow at a higher level above the sea than the lower part. It is not, however, this circumstance which determines the distinction, but the degree of slope of the river bed, and the construction of the river banks. On an average, the fall of the river is by far the greatest near its source. The mountain stream leaps foaming from the rocky height, carrying down with it stones, earth, and *débris*, and working continually at the formation of its own channel. The speed of the water is of much greater consequence than its volume, and we find the mountain streams hollow out their channels much more quickly than slower and fuller rivers. Of course it must not be forgotten that the high-water-mark of mountain brooks is extremely unequal. Slender threads of water, swollen by heavy rains or melted snow sent down by the south wind or the avalanche, are changed to mighty torrents, which plunge into the valley with the roar of thunder, annihilating all that opposes their path. The observant traveller can generally determine the character of the stream by the surrounding neighbourhood. The worn and hollow rock, with its sudden depression, tells its own tale of desolating floods poured down upon the valley at their feet. Laden with *débris*, the swollen brooklet becomes a turbid, muddy torrent, carrying down and dashing together heavy masses of stone in its foaming depths. Where the channel opens into a wide valley, mounds of earth and stone are generally found, left by the water suddenly checked in its downward course. But many of the mountain streams flow down into deep narrow channels carved by themselves in the solid rock in the course of thousands and thousands of years. After heavy rains these narrow channels are often filled to a depth of one hundred feet with foaming water, which shoots down with lightning speed into the valley. Nothing can stand before the force of these torrent streams, and, aided by the atmosphere, they work incessantly at the disintegration of the rocks, breaking up the masses of stone, and carrying away the covering of earth. Of the speed with which a stream of this nature can cut through the hardest rock, the Simeto, a river in Sicily, affords the best example.

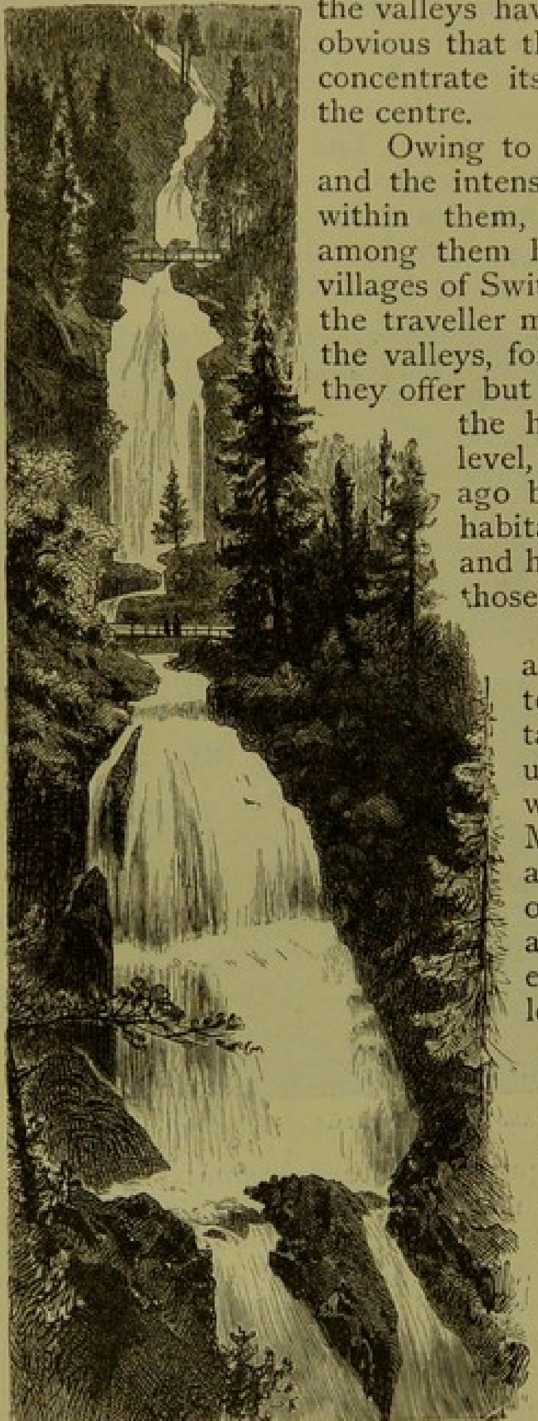
During an eruption of Mount Etna in the year 1603, it was dammed up by the lava; and at the present day the outlet which it has opened for itself in the solid mass of basalt measures twenty yards wide and thirty deep. The sawing asunder of the hard rock, which has in this instance been effected almost before our very eyes, has been going on in other places from time immemorial. For example, the ravine into which the foaming waters of the Tamina fall, and in which the sun even on the longest day shines for six hours only, has been cut out of the rock by the fall of the torrent in the course of myriads of years. And in the same manner the Reusz is working incessantly at the cleaving asunder of the marvellous fissures of the central Alps. The cause of the rapid crumbling away of the rocks in the Rhenish valley of Graubunden is the amount of carbonate of lime which they contain, and which, being dissolved by the pure water, changes the mountain slopes into an easily friable mass.

The erosive effects of these mountain streams are seen even in the midst of parched and dried-up wastes after a long course of heavy rains. A grand example of this law working on the torn and porous mountain land of Asgar in North Africa is related by an eye-witness who describes the effect produced by a heavy rainfall. The traveller was on his way to Agades, and in lat. 19° north he was overtaken by violent storms of rain at the western side of a mountain range from 4,200 to 6,300 feet high. The valley was rapidly changed into the broad channel of a rushing torrent, with a current strong enough to carry off a camel for more than half a mile. A little before noon the flood began to turn towards the lower part of the valley, and on the next day it presented a spectacle of terror, recalling the pictures of the deluge.

FALL OF THE KERKA AT SKARDONA, DALMATIA.

Half an hour after noon the waters began to abate. A similar rainstorm has been seen in the desert of Gobi. In the parched mountain ranges of Ala-schan, surrounded on all sides by sandy wastes, Preschewalski was surprised on the 1st of July, 1873, by a terrific downpour which lasted for several hours, bringing to light many mountain streams hidden in deep ravines, tearing down heavy masses of rock, which fell with such violence that the earth trembled as if from the shock of an earthquake. The travellers had barely time to escape to a place of safety.

The rivers of the Himalayas and of Thibet present spectacles of the same character. In the upper part of the Ganges, Indus, and Sadlasch, these streams have dug for themselves beds of alluvium and solid rock, which in some places are 1,093 yards deep. The wonderful effects of erosion in the mountain ranges of Northern India are called forth by several reasons, of which the following are the most important. In the Himalayas the rainfall and the melting of the snow are the most evident factors of this erosive force; but here, as well as in Thibet (although, indeed, the yearly rainfall in the latter country is very inconsiderable), it is very greatly intensified by the narrowness and steepness of the valleys. For where, as in this country, the valleys have almost the character of a ravine, it is obvious that the whole force of the swollen water must concentrate itself in sharply defined boundaries along the centre.

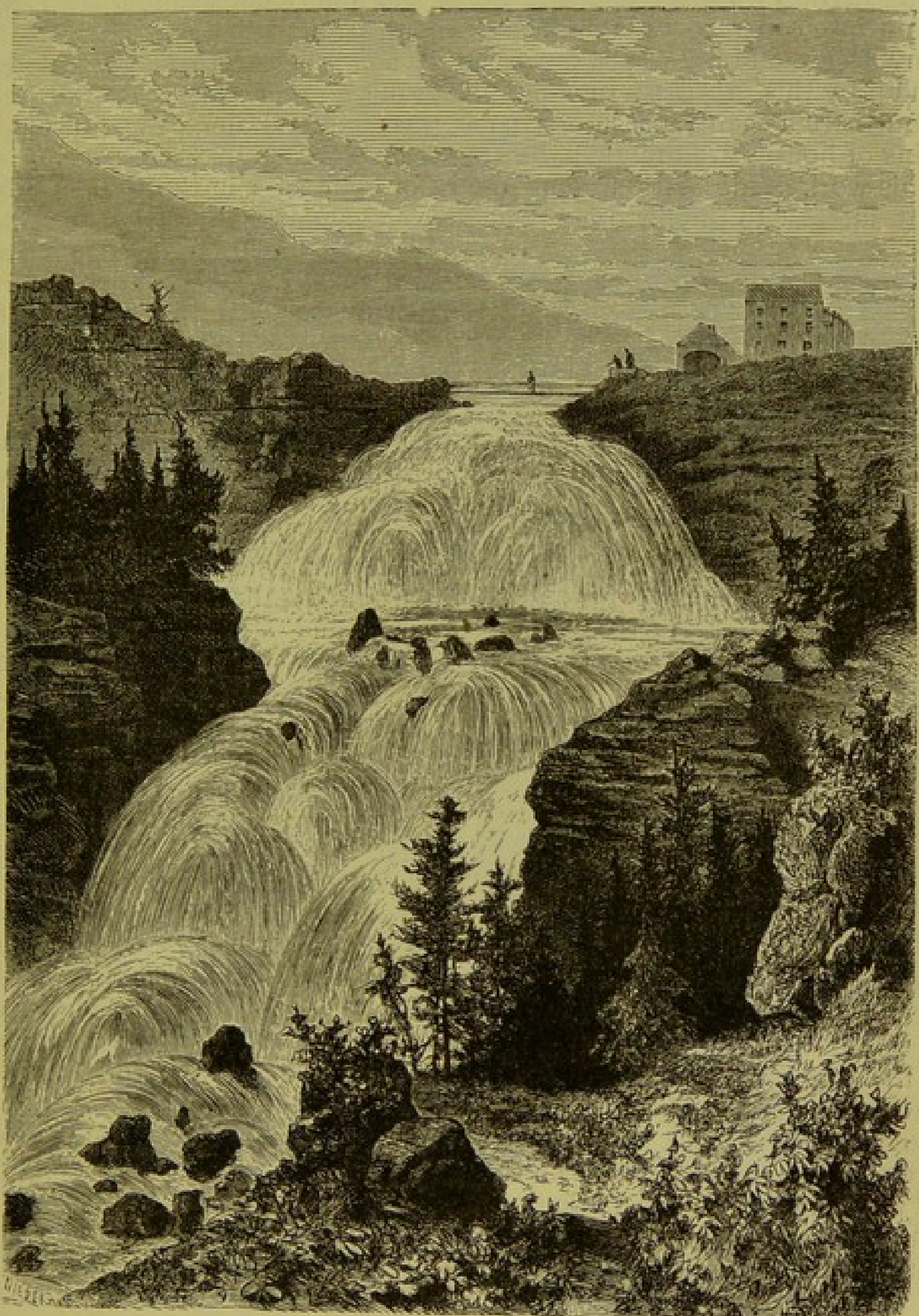

The Giessbach Fall in Switzerland.

Owing to this peculiar characteristic of the valleys, and the intensified effects of the erosive power of water within them, the numerous inhabited places found among them have a different aspect from the Alpine villages of Switzerland, for instance. In the Himalayas the traveller must not expect to find villages nestling in the valleys, for the latter are so steep and narrow that they offer but a contracted, inhospitable resting place; the houses are perched high above the water level, on terraces which were formed centuries ago by the same destructive floods. The inhabitants have taken the kindly hint of nature, and have either formed new terraces, or widened those made ready to their hand.

In the lapse of long periods of time the appearance of mountain ranges is wholly altered by the effects of erosion. Our mountains of to-day are but the ruins of former upheavals, the more or less imposing relics which still defy the attacks of air and water. Many of the bold masses of our mountains are merely formed, like the so-called *Tokens* of the African desert, by the effect of wind and water, which have torn away the softer earth that formerly surrounded them, and left them standing, thanks to the presence of some harder ingredient in their composition. All are destined to disappear—some sooner, some later; for water will endure no inequalities of the surface over which it flows. On the other hand, if the opposing forces which raised the mountains still continue, fresh elevations will arise, and who can say whether the levelling power of water will gain the final victory?

The French Alps belong to those districts of the earth which present numerous instances of the rapid progress of destruction; for the ignorance and folly of man have helped on the inevitable processes of natural laws. In the provinces of Dauphiné and of Provence, the mountain slopes, now bare and exposed, were formerly overgrown with meadow land and forests, which retarded the violence of the rainfall, absorbed a great quantity of moisture, and kept the fruitful soil cleaving to the barren rock. In the course of centuries the forests were cut down by greedy speculators and foolish peasants, who wished to add a few more plots of ground to their meadows and fields among the hills, and in so doing destroyed their own property.

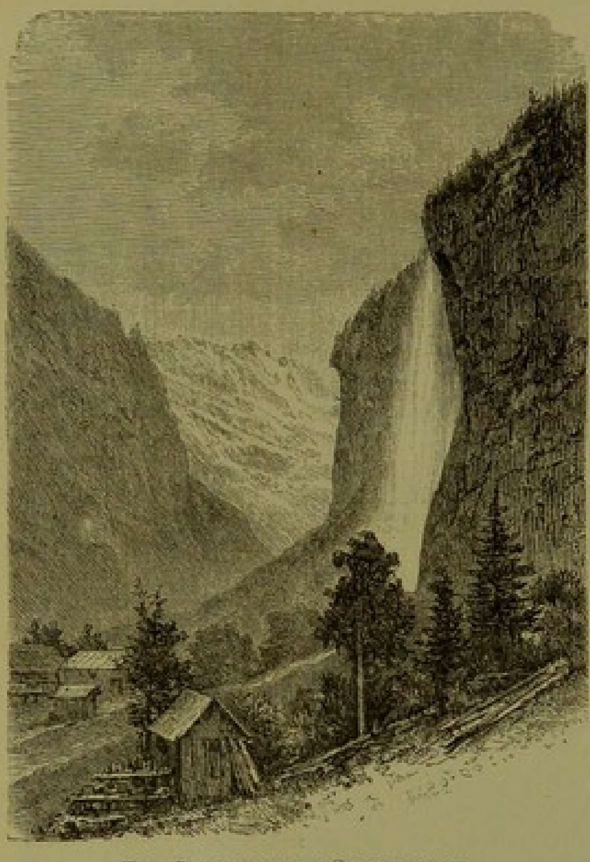
Now, where the rain and snow, no longer checked and held back by the



Tosa Fall in the Valley of Formazza.

branches of the trees, rushes madly down the bare slopes, it carries stones and mud into the valleys; goats and sheep eat the poor remnants of roots and herbs left behind; gradually the fertile coating disappears, and the barren rock protrudes; deep channels and ravines carve furrows in the slopes, and make a way for desolate mountain streams unknown before; the water, once the beneficent means of carrying salts to the roots of the trees, and slowly penetrating the grateful soil, is now an engine of destruction. Ravines appear here and there along the slopes ever since the felling of the trees, and lengthening and widening in the unresting progress of decay, they meet with corresponding ravines from the opposite slope, and finally cut asunder the ridge of the chain into separate isolated peaks, each surrounded by its desolate heap of stony *débris*. Many a peak can be seen from year to year created and broken up by this process. In some places not a green twig is seen for miles; here and there a scanty patch of coarse grass is found along the hillside, and the ruins of houses are mingled with the weather-worn decaying rock.

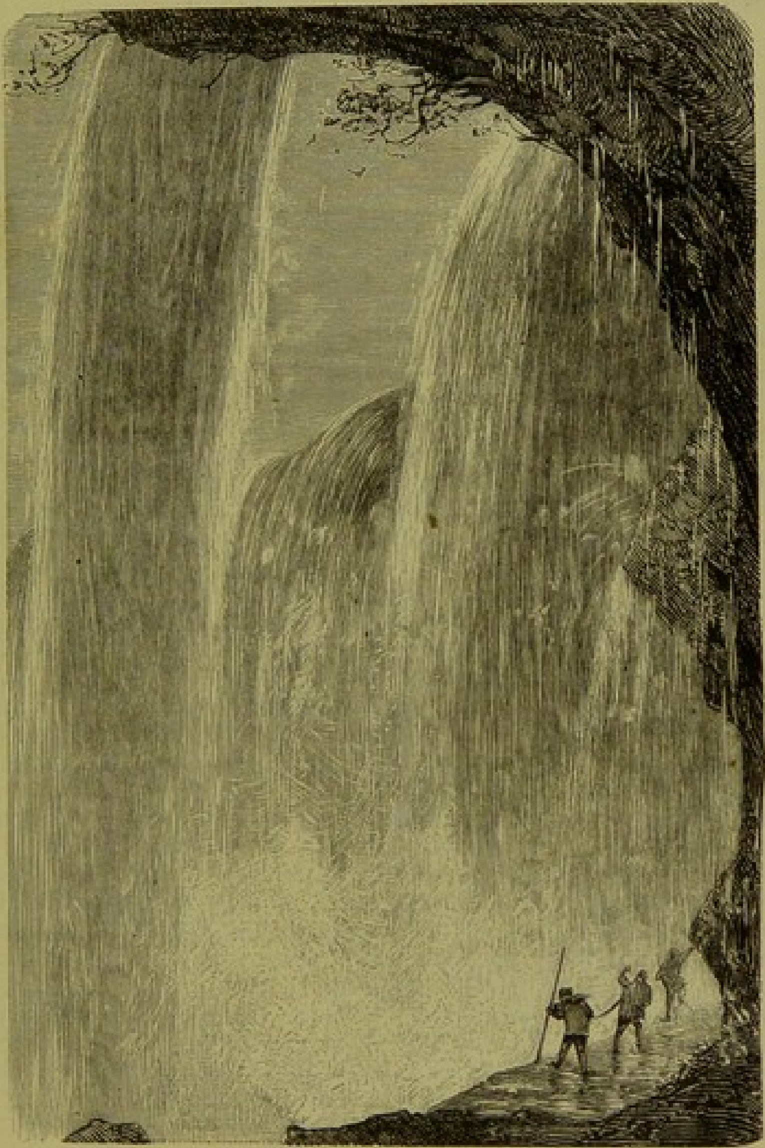
This work of desolation going on before our eyes in the French Alps is of great interest to the historian, and gives a valuable hint as to the reasons of the depopulation of many a tract of land in Syria, Asia Minor, Greece, Africa, and Spain. The axe of the woodman has been no less disastrous to many a flourishing tribe than the sword of the conqueror. At the present time we see the southern Alpine valleys become less populous year by year; and one may almost predict the point of time at which the departments of the upper and lower Alps will be deserted by their inhabitants, unless timely and stringent measures are taken to stay the work of destruction.



THE STAUBBACH IN SWITZERLAND.

Waterfalls are the constant attendants of the upper courses of rivers; but they are also met with in the middle part of the course, where, indeed, they are, as a rule, grander and richer in volume. The Staubbach, in the valley of Lauterbrunnen, rushes down from a height of 280 yards; the Marboré, near Gavarnie, in the Pyrenees, is almost twice as high. Both, however, are surpassed by the falls of the Rhine near Schaffhausen, where the mass of water plunges over a precipitous wall of rock 120 yards wide and twenty-five high.

But what is this in comparison to one which has as yet been beheld by comparatively few Europeans, namely, the Victoria Falls on the Zambesi? Mohr, who undertook the tedious and dangerous journey to this waterfall, considers that it surpasses the Niagara itself in grandeur and beauty. One thousand yards in width, the magnificent river pours its waters into a rocky chasm 300 feet below, which cuts across its bed at right angles, and is bounded by rocks sixty feet apart. As the water comes nearer to the falls, it rushes towards them with giddy speed, and the long lines of foam upon its surface give it the appearance of being at boiling heat. Near the western shore is a little island about 120 feet from the bank, where the water, with a mighty roar and swirl, arches over like a wave of the sea, and plunges to the depth below. Travellers who are proof against attacks of dizziness can stand here upon a ledge of rock which overhangs the western side, and see to the left, close beside them, the fall just described. The long line of the principal falls in front is of course only partially in sight; for the air, pressed down, contracted, and filled with watery particles, frees itself with a violent effort, and rises in spectral masses of steam and vapour, which rest like incense clouds above the mighty altar of the waters. The spectator, standing on this point of rock, and looking steadily down into the whirling, foaming, hissing chaos at his feet, wrapped round by the din and fury of the raging elements, is thrilled to his



Under the Falls of Niagara (Canadian side).

inmost heart by the weird, unearthly, indescribable howl and roar which seeks to stun and deafen him, and wonders how the rocks themselves, those hard ribs of the solid earth, can resist the fury of the onset. After the Zambesi has forced its masses of water through the narrow pass 100 feet in width, it rolls on in three or four snake-like curves. In the narrow river bed the depth of the water must be enormous. The sides are formed by perpendicular walls of rock 500 or 600 feet high, and absolutely inaccessible.

The Niagara Falls are the most famous of the earth's waterfalls, and are visited by crowds of admiring spectators. They are also the best known from a scientific point of view. The river Niagara flows through Lake Erie, and falls into Lake Ontario, which lies 346 feet below. The falls are seen above Lewiston; and if the course of the river is observed between Queenstown and Lake Erie, the channel cut by the stream in the rock is distinctly traced, showing how in the course of thousands of years the cataract has retreated. The consequence of this continuous retreat is obvious. In thousands of years to come the great lakes will gradually run dry, as soon as the waterfall has sufficiently drawn back, and green valleys, busy towns, and an active population will be found where the steamer now furrows the surface of the lake.

Marcou, who has visited the river many times within the last quarter of a century, divides its course between the two lakes into three parts of very opposite character. In the first part, between Lake Erie and the great falls, the river is broad, and flows majestically through level plains. Its banks are shallow, and its surface dotted by numerous islands, one of which, Great Island, divides it into two branches, which do not meet again until they approach the falls.

The second part extends from the falls to Lewiston. For seven miles long the stream narrows, and forces its way through mighty walls of rock 200 or 250 feet high, the difference of level between the falls and Lewiston being 100 feet. This rocky chasm is the work of the waters themselves; in pre-historic times the falls *wandered* through the district, the heavy masses of the cataract gradually washing away the great limestone rocks and the substratum of yielding clays, and winning their way to their present position. It is probable, however, that near the place where Lewiston now stands several falls rose one above the other, the form of the cataract being essentially modified by the hardness and power of resistance of the rock over which it falls. As the strength of the chalk layer increases in proportion to the retreat of the falls, the edge of the precipice becomes more and more massive, and consequently presses with heavier weight upon the weak, crumbling, base of marl on which it rests. Moreover, the water is hurled with violence against the rocky walls, and currents of air amounting to severe storms are formed below. The water sways and whirls beneath the gigantic stamper, which crushes and annihilates all below, and the wearing away of the strata must be all the more perceptible as the level of Lake Erie is reached. The falls of the Ohio at Louisville present the contrary phenomena to those of the Niagara. In the Ohio Falls a base of hard limestone lies beneath black clay, over which the falls precipitate themselves, gradually wearing away the upper strata, so that in course of time nothing will be left but steep walls of rock. This method of foretelling the future fate of the Niagara and Ohio Falls is the result of long and continuous observations, and is shared by the inhabitants of the respective neighbourhoods.

The best position for obtaining a good general view of the falls is found near the hotel at Clifton, on the Canadian side, and is called Victoria Point. From this place Marcou, after a lapse of fifteen years, did not discover any alterations in what is called the American side of the falls, and which is separated from the Canadian by Goat's Island. But in the latter the changes were very striking. The famous Table Rock had well nigh completely disappeared, part of it having fallen in 1850, and another part in 1857. The so-called Tower of Terrapina stands much nearer the edge of the fall than it formerly did, and several masses of rock near it have been already torn down into the abyss. The volume of water on the American side is slowly decreasing, while that on the Canadian side, especially near the Tower of Terrapina, increases. The latter portion of the fall retreats much more quickly than the former, which will be laid completely dry as soon as the Canadian falls reach the three Sister Islands, as it will do within 800 or 1,000 years. Goat's Island will then be joined to the dry land. The retreat of the Canadian falls is of course accelerated by the increased volume of its water. At present this part of the fall is more than 2,100 feet wide and 154 feet high; on the American side the same dimensions are respectively 936 and 163 feet. According to an approximate reckoning, about a thousand million cubic feet of water is dashed down the precipice every day, and the thunder of the falling mass can be heard ten miles away.

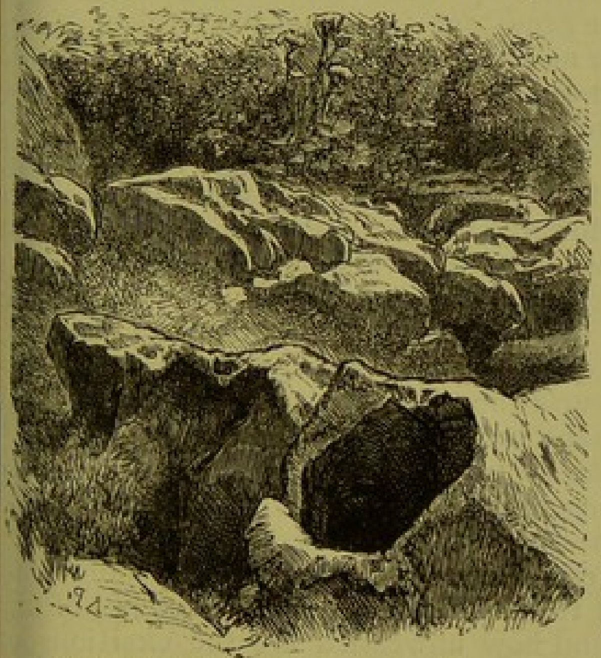
The third part of the Niagara river extends from Lewiston to Lake Ontario, a distance of several miles, with a difference of level of four feet. The river is navigable here, but shut in between high rocks, and full of eddies and cross currents. It has much more resemblance to the second part of the stream than to that which flows between Lake Erie and the falls.

The effects produced by the Falls of Niagara were probably called forth in remote ages along the course of the Elbe. The origin of its valleys and those of its tributaries in

"LIGHT OF THE OCEAN.

Saxony point back to similar processes. The labyrinth of grotesque blocks of stone was originally a flat monotonous level of horizontal strata of sandstone, extending at the level of Königstein and Lilienstein. The Elbe, then seen to be the outflow of some Bohemian lake, flowed over this level, and somewhere in the neighbourhood of Pirna fell over the sandstone rock which rises out of the plain. Its waves undermined the rock, which broke up, and allowed the waterfall to advance up the stream, and force its way through the sandstone plateau, cutting it right through to the last dam of the Bohemian Elbe-lake near Tetschen, where the dam broke, and the whole lake emptied itself into the chasm. The modern bed of the Elbe is 885 feet below the original one. By this alteration of level the affluents of the principal stream were enabled to develope the force of their fall. They cut deep down into the sandstone forming those wonderful chasms and fissures which wind in tangled mazes through the other parts of the rock, the ruins of a desolated landscape.

To the erosive power of water we owe the formation of the deep holes, or so-called Witches' Caldrons, vertical cylindrical cavities, the bottom of which is often covered with smooth round stones. They are met with in places of the most opposite character—in Norway and in India; and they are not restricted to any particular kind of rock, for they are found in the granite of Finland and the limestone rocks of Jura. They are generally of great antiquity, belonging to an epoch when the distribution of water was wholly different from what it is to-day. The general opinion concerning those holes is that they were formed by violent eddies which washed the stones round and round for long ages above the same place. The hardest rock would in process of time be hollowed out by this action of the water above it. In India, on the banks of certain rivers, holes of this nature have been seen, where the water entered from one side, was driven back by the shock, and did not flow on till it had been forced round in a circular movement. The so-called glacier-mills, or rifts, down which pours the melted snow laden with sharp stones, can also form these caldrons: indeed, some have been found formed by the plastic glacier ice laden with its freight of stones.



WITCHES' CALDRON IN CHEMNITZTHAL, SAXONY

MIDDLE AND LOWER COURSE—CHANGES IN THE BED OF THE STREAM—DELTAS.

The middle and lower parts of the river's course are quieter and slower, owing to the fall being so much less. The volume is swelled by the influx of many affluents; and the river, so enriched, flows tranquilly onward towards the sea. The stream now indulges in capricious loops and curves; the course being marvellously changeable, and showing such a strong tendency towards the displacement of its old channel, that many rivers have to be kept by force and artificial aid within their proper bed. The heavy blocks brought down from the mountains in the earlier part of the course become more and more broken up; and are at last rubbed into sand or dissolved into mud. The further a stream is traced downward to its mouth, the finer is the sediment found within it. The amount of sediment varies considerably, but is always greatest at high water, when even a generally clear stream presents a turbid appearance. To gain an idea of the quantity of solid matter withdrawn from the land and carried down to the ocean, we may remember that the Ganges, according to careful investigations, pours yearly into the sea about 409,600,000,000 cubic feet of floating and dissolved particles ; a mass which, if spread over a surface of sixteen square miles in extent, would raise it to a height of fifteen feet. Far greater is the amount of mud carried down by the Hohang-Ho, which well deserves its name of Yellow River. This wonderful stream is said to carry down every day 3,072,000,000 cubic feet of sediment; and the Peiho, at Tientsin, appears as a perfect mud river flowing with great rapidity between its banks. The solid particles carried down by the Rhine are, comparatively speaking, inconsiderable, and yet in the course of 5,000 years they would amount to sixty-four cubic miles. This Rhine *débris* comes from the regions below the Swiss lakes, the sandstone ranges of the Neckar, Main, and Moselle, and the clay basin of the neighbourhood. Whole mountains flow unseen through the watery masses, and all that is brought down by the upper and middle course serves, when poured into the sea, to form the base of some new tract of land. In a far distant age, when the strata between Jura and Taunus were uplifted, and formed a diagonal plain framed by the Vosges and the Schwarzwald, and sloping gently towards the north, the Rhine then flowed 822 feet above its present level. Even yet the former level of the river can be traced, and the deposits of stone and *débris* above speak clearly of the course of the ancient stream. Little by little the waters cut out their channel, eating away the surface of the old plain, and piling up its separate components at the former mouth. Of course the tributaries of the Rhine were all upon the same level, and sank as it sank into its new bed.

Great interest has been felt in the washing away of the soil in many river basins. It has been found that during 729 years the basin of the Po has sunk by one foot; the Rhone has sunk one foot in 1,528 years, the Tay in 1,842, the Danube in 6,480. These estimates must not be looked upon as more than approximate ; but they are sufficient to shew what immense stretches of dry land are being carried into the sea, and how unwearied are the exertions of the rivers to restore perfect equality of level.

The Colorado, in North America, furnishes us with a splendid example of the formation and sinking of a river bed. Nothing in the world can be compared with it, and to find formations worthy of being placed beside the ravines of the Colorado we have to leave this planet altogether, and turn to the clefts and fissures of the moon. In a course of more than 270 miles the Colorado has hollowed out its bed to a depth of 2,186 yards, in certain places going down through all the intervening strata to the bare granite. Sheer walls of rock rise from the awful abyss, into which the sun's rays only fall for a few hours in the course of the day.

Our knowledge of this marvellous river basin is altogether of recent date. About one hundred years ago a Spanish priest visited Arizona, and in his description of the journey he says that the river banks were so high, that a rock rising out of the river, and being in reality as large as the Cathedral of Seville, looked, when seen from the cliffs, no larger than a man's hand.

This was well calculated to arouse the curiosity of the explorer. In the years 1869—1874, an expedition, under Major Powell, was sent out by the United States, to trace the mysterious, unknown course of the Colorado; and after great dangers and almost insurmountable difficulties they succeeded in tracing it from its source to the boundaries of

California. Thanks to their exertions, we have now learned to know something of the desert tracts extending from Wintha Mountains on the Pacific Railway, through Colorado, Utah, Nevada, and Arizona, to the Gulf of California.

This vast territory, embracing an area of more than 100,000 square miles, is entirely destitute of grass or trees. Nothing is seen but red-yellowish steppes, with scattered salt lakes and mountain ranges, not like the plains of the Platte and Arkansas, covered with fertile soil, but condemned to everlasting barrenness.

Not only the Colorado itself, but its many affluents, such as the Virgin, the Kanah, the Paria, the Escalante, and the Dirty Devil, on the west; and the Green, the Yampa, the San Juan, and the Chiquito, on the east, have their own deep, winding cañons. The very tributaries of the tributaries have special cañons; each brook, nay, each rivulet, formed by the rain before our eyes, lasting while it lasts, and disappearing as it disappears, has its cañon; and this fact will help to give us some faint idea of the character of the sandy waste which forms the upper basin of the river. It is a perfect natural labyrinth, and for the most part inaccessible to the foot of man. It is like a mighty city turned to stone, whose streets are suddenly flowed through by raging streams, and where the houses are represented by smooth walls of rock ten times the height, forbidding any descent into the streets. All the scenic peculiarities of this part of the country near Utah and Arizona are upon a gigantic scale, weird, awful, and forbidding. The rivers flow at literally inaccessible depths, undermining their banks and rock, fretting against the prison they have themselves hewn. Far down in these narrow chasms, the captive waters roar and surge, pouring over falls and cataracts to reach the lower levels of California; and above them, on the summit of the rocky walls, are bare, treeless plains, showing the naked rock. Here and there, where the rocks are formed of marl, they are already partly eaten away and decayed, and the traveller walks through a loose, yellowish-red material, as if he were in a bed of ashes. In other places, where the marl is replaced by a soft sandstone, the surface is so worn that it is covered with drift-sand of the most varied colours, from dark red to vivid yellow.

It is the land of cañons, treeless, bare of all vegetation, shunned by living creatures, avoided by man; a desert and a labyrinth at once, a fragment of the under-world brought to the surface. Except the arctic regions, lying stark under their shroud of ice, and except the desert of Thibet, there is no such desolate, appalling waste upon the earth as this cañon district of the Colorado, no Sahara more inhospitable than the land lying to the south of the Nevada State. The only entrance to it lies through the cañons. Many perhaps have sought and entered their labyrinths, but few indeed have emerged again into the light of day. Generally the first few miles have been fatal to the rash intruder. The daring hunter either was precipitated from the rocky height, and dashed to pieces, or drowned in the muddy, roaring flood below; caught up in the myriad eddies, and maybe cast ashore some weeks afterwards. The boats and rafts launched on the terrible waters were crushed against the rocks, or overturned by the swift fall of a cataract. Even those who surmounted the first dangers were mocked by the evil genii of the place, and perished of thirst in sight of the fathomless floods below. Wasted with famine and hardships of every kind, it is said that the few who escaped from the cruel region with their life suffered the loss of reason. It was hailed as nothing less than a miracle when the expedition under Major Powell succeeded in passing through the district of the Colorado, although they had lost all their property, and brought nothing with them but their bare lives. It is from them and from Lieutenant Ives that we know all that is known of the country.

In the upper course of the river the cañons are more numerous, but lower, if the word lower may be applied to a rock five times as high as St. Stephen's in Vienna. In the beautiful cañon of Lodore, named after Southey's well-known poem, the walls rise to about 3,150 feet.

In some places farther up the stream, for instance, at the foot of Grey Cañon, grey towers of rock rise up sheer out of the water, as if built and chiselled by the hand of man. They are rocks worn by the storms of ages, till only a thin rocky spire or heavenward-pointing ruin is left like the bare skeleton of some monster of the primeval world.

Along the cliffs, extending far inland, and even on their summit, are seen the strongest obelisks and blocks, as if the place were the burial ground of Titans, over whose graves colossal monuments were standing. Dens and open graves are found in the walls of the cañons, as if waiting to receive the rash intruder into the consecrated resting place of the genii, and greeting him with their voiceless *memento mori*.

These strange forms have gained for the cañon the name of Monument Cañon. From the mouth of the river Paria the cañon receives another character: the stream has now entered the limestone formation, having cut its way through the smooth marble rock without the slightest sign of side passage, cleft, or *debris* of any kind. It is a smooth, unbroken passage between walls of brilliantly polished and often richly coloured marble, higher than any cathedral in the world. White, grey, saffron, rose, and purple blend and intersect in the veining of these giant walls, half a mile high. For sixty-five miles, from the Paria to the Chiquito, they enclose the rushing stream, and form a magnificent corridor leading to one of the greatest wonders of the world—the Grand Cañon of the Colorado.

THE GRAND CANON.

The river flows between vertical walls, one mile in height, toward the open desert plains two hundred miles away. Seen from above, its mighty waves, as they rise and dash against the rocky walls, look shrivelled and dwarf-like, the great stream dwindles to a thread, men seem like ants lost in the depths. One mile high! The distance is considerable when measured horizontally, but it is doubly hard to realize when raised perpendicularly above our heads.

For a thousand feet, or about double the height of the Great Pyramid, these vertical rocks consist of granite, which appears to have been hewn and fashioned by some Titan's hand; and upon this pedestal of primeval stone, cliff upon cliff rises to the summit, and that summit is the surface of the earth. Below, on the banks, all is black, contracted, gloomy; higher it is red and rose-pink, grey and orange, with side cañons and clefts, a very tangle of rock. The farther one advances, the deeper is the ravine, until to the mile above our heads a half-mile has been added, and the awful cliffs rise seven thousand feet above the river.

From time to time the cañon is filled with clouds; they sink slowly downward in heavy masses, and enwrap every object in close grey mist. Sometimes they hang across the cliffs, and throw over the cañon a gloomy roof of storms. Clouds for the roof, black granite for the walls, and for the floor a hissing milk-white foam; for the stream is lashed into unresting fury. Suddenly an angry squall shrieks down one of the side cañons, seizes the cloud, and rends it open, letting the clear blue of the starry sky look down upon the white fury at its feet. It seems as if the heavens rested upon the summit of the cañon, so high are its walls of rock, so deep the rushing river. Now and then the clouds tear themselves loose from the entangling projection of rocky spire and pyramid, and flee before us; the grey veil disappears, the points and sharp edges stand out again in bold relief, a study of natural gothic. After awhile the wind, rushing over the desert plains above, gathers into storm and tempest, the rain thunders down the myriad mountain streams, and mighty cataracts hurl themselves from the gigantic rocks into the foaming flood below with such force that the spray is dashed high up the face of the cold granite of the cañon.

And this panorama extends for two hundred miles. Sometimes the granite is replaced by other kinds of rock. But be it what it may, marble, or granite, or sandstone, the water has cut its way through all, and even the hardest strata have yielded to its resistless violence. The book of geology lies open to the gaze of the student. Here he sees the lava, basaltic and ash strata of volcanic periods, the sandstone and conglomerate of the sedimentary rock, and the granite of primeval ages.

Nowhere are grander mountain gorges to be seen. What are the Afra valley, the Via Mala, the Gorge of the Tamina, in comparison? The height and mass of Mount Washington have been admired; well, let the whole mountain stock be cut asunder from its highest crest to its base, and its chasm of many thousand feet in depth will scarcely be as deep as the cañon through which the Rio Colorado pours its waters.

But more wonderful, perhaps, than the depth of the grand cañon, more wonderful than the mighty piles of rock rising to meet the sky on each side of its angry river, is the fearful, resistless force of the water which has in the course of ages created this miracle in stone. The elements wage tireless war against the works of man, but their hatred one against the other seems yet more insatiable, more violent, more inexorable, and more deadly in the eternal war of extermination in which they have grappled together since the creation—a struggle seen in its grandest aspects in the cañons of the Rio Colorado.

The middle course of the stream shews many terraces, the remains of a former and larger river bed. Not that such terraces are always the signs of the former position of the stream; they are formed sometimes simply by the floods pouring down from streams which in their ordinary condition are small and insignificant. This fact was first established by the examination of the rivers of India; and it is found that the large occasional bed of the flooded river is greater in proportion to the small size of the ordinary channel. The course of the Indian rivers flowing through the plains is divided into two stages; one filled with water for the average height, and a higher one for the rainy seasons. The latter channel is left dry during the greater part of the year, and along the course of the Ganges yields plentiful crops, but on the Indus is choked with sand. When the rainy season sets in, the rivers soon rise into the larger bed; but disastrous floods seldom occur, unless, which rarely happens, the waters overflow the banks of the wider channel.

Where the river pours itself into the sea, the swiftness of its current receives a sudden check, and gradually decreases in speed, while a large quantity of the sediment it carries down falls to the bottom. The larger rivers, it is true, do not yield at once, but strive to force their way far out into the ocean. The current of the Congo, for instance, is perceptible for more than 180 miles beyond its mouth, and the waters of the Amazon are said to be distinguished 225 miles from the coast. But this is true, of course, of the upper strata only, the lighter river water spreading abroad over the salt waves of the sea. The force of the river current being broken near the mouth, it is here that the greatest deposit of its *débris* and sediment takes place. The larger substances sink to the bottom at once, the finer ones follow them more slowly, and some float out to the open seas. This natural separation is disturbed by the changeful level of the rivers and the movements of the sea, but in all cases heaps of *débris* are accumulated from the lower strata of the stream, and piled up near its mouth. Wherever this *débris* rises above the sea level, joins the mainland, and exhausts its subterranean channels, a *delta* is formed. There are very many river mouths where this formation is not found; the *débris* extends far and wide, forming sandbanks, ridges, and bars, but remaining always below the surface. What, then, is the cause of this difference? What conditions are required for the formation of a delta? This question has furnished a frequent subject of debate between geographers, but the answers given to it are very different. In our opinion, the problem has been solved in a recent work by Credner. He declares that the sedimentary deposits brought down by the rivers, the rapidity of their course, their depth before they reach the sea, and the mechanical action of the latter upon their waters, have only a local influence upon the formation of deltas, while on the other hand it needs the effects of secular upheavals of the coast line and depressions of the water level of inland seas to produce the rise of deltas above the surface of the sea, as they have done in places which were apparently unfavourable.

Conversely, the depression of the coast line and the rising of the level of inland lakes not only prevent such formations on wide flat coasts of continents and inland seas, but cause deltas already in existence to disappear again beneath the waves. Where the conditions required for the formation of a delta continue, the further development and advance of the land into the sea continues also, and gradually raises the sea's bed. A striking example of such a rapid advance is seen at the mouth of the Mississippi. The delta presents the general appearance of a low level surface partly lying under water, thickly overgrown with marsh plants and sedge, and intersected by numerous channels and lagoons. The river loses its wealth of waters at New Orleans, where it gradually empties itself into numberless swamps, which find an outlet in several small channels. Only three arms or "passes" of the river can be distinguished, and they are continually being choked with mud. The river never knows which outlet to turn to; sometimes one, sometimes another, carries off its waters. At the present time its waters flow through the *Passe à l'Outre*, but how long they will continue to do so no one can say. The progress of the delta is rapid only at the passes, where it is said to amount to eighty-eight yards in the course of the year. When the water goes down, heaps of mud and sand are formed in semicircular bars across the mouth of the river. At high water the river breaks through these bars, and spreads out right and left like the two valves of a folding door, so making a beginning of future dams, between which the river will afterwards flow on into the Gulf of Mexico.

A strange and as yet unexplained influence is exerted by the islands or so-called "mud lumps" which rise up on each side of the bars. They are the despair of the explorer, and the evil genii of the Mississippi. They rise up suddenly, gradually increasing in circumference, and generally assuming the form of a cylindrical hill, from the sides of which pours a constant supply of muddy water. Many such mud lumps never rise to the surface of the river, others rise above it, and often bear upon their muddy crests the ruins of sunken ships, as a proof that they have risen from the bottom of the stream. One of the largest of these islands rose in 1875, from the *Passe à l'Outre*. It began slowly behind some old mud lumps, and spread out in from ten to twelve feet of water. The old islands, which were too hard and too deeply imbedded, were not raised with it, but the stiff mud forced itself upward along their sides like lava under a heavy pressure, and covered the old lumps. Numberless gas springs bubbled up from the surface. In thirty hours the new island was formed, having a circumference of more than thirty acres. We will not enter into a consideration of the various hypotheses which have been put forward to explain these phenomena; it is certain that the accumulation of gas has a great deal to do with their appearance.

The delta of the Ganges owes its origin to the masses of mud carried down by the river; the eastern branch advances much more rapidly than the western, because the Brahmaputra carries down more mud than the Ganges itself. The lower stratum of the delta is formed of sand corresponding to the former bed of the sea. Over this are strata of turf, clay, and mud, extending seawards for more than 725 feet; the delta is the district of constant moisture, not only in consequence of the large arms of the river, but also because of the moisture-laden wind to which it is exposed. The ground water is everywhere found at the most a few feet below the surface.

In the delta of the Nile, the original bed of rock lies some ten yards below the surface, below the rich black mud of the river; the district round the mouth is perfectly flat, and crossed by numerous arms and channels, of which those on the eastern side are gradually becoming choked with sand.

In the days of Sesostris, thirty-three centuries ago, a great part of the delta of the Nile was nothing but marsh land, the reclamation of which, by means of dams, was already begun. But, although the Nile created the delta, centuries have passed since it ceased to carry on its work, and the coast of Lower Egypt is gradually sinking. For centuries past the formation of land along the coast has been restricted to the building up of narrow tongues of land on each side of the principal mouths of the river; and that even these are not formed by the Nile itself, but by deposits carried by side currents along the coast, and heaped up by the action of the north-west winds, which blow for nine months in the year, is proved by the fact that they are composed of a mixture of Nile mud and the sand of the Mediterranean. There can be no question at the present day of any continuous land formation effected by the Nile, and for many years no trace of any fresh deposit of land has been found along the coast of Lower Egypt; on the contrary, long stretches of the low-lying delta within the district enclosed by the banks have been won back by the once excluded sea. The water has spread over fertile plains, the former home of pastoral tribes; lagoons flow above what were once thickly populated districts; villages and towns have sunk beneath the waves of the bays of Menzaleh and Aboukir, under whose surface the ruins of their buildings are still visible. The land-forming deposits of the arm of the Nile which once flowed through the district have sunk below the water, and are still in perfect preservation beneath the surface: in the upper parts of the delta alone, the raising of the alluvial soil still continues, but this is wholly due to human interference; the muddy waters of the Nile are conducted across the plain through numerous channels, carried into the fields, and, by the construction of artificial dams, forced to deposit its fertilising substances.

The seaward advance of the Rhine delta has long come to an end. The Netherlands, that old bed for the Rhine's deposits, can only be protected from the inroads of the sea by the constant and untiring exertion of human ingenuity; were it not for man, who is perpetually contending with the sea for the soil on which he lives, the delta of the Rhine would long ago have sunk beneath the waves.

Lakes.

In common language every large depression of the land which is filled with water is termed a lake; and by this mode of speech widely different geographical ideas are classed together. What an immense difference exists between the vast expanse of the Caspian lake-sea and the lonely tarns met by the wanderer unawares in the high levels of the Alpine ranges, some 9,560 or 9,840 feet above the sea! What a contrast between the mighty lakes of North America, which exert a climatic influence like that of the ocean itself upon the adjoining coasts, and the countless tiny lakelets which are scattered over the plains like stars over the midnight sky, lost in their fringe of sedge, and dying out in soft, boggy moorland; or between them and the lagoons, with their shallow reaches of salt water cut off from the sea by a rampart of sand! And the geographical aspect of the different kinds of lakes is not less varied than the sources from which they arise. Many of them—indeed, almost all which are found situated at the same or on a lower level with the sea—are parts of the ocean bed cut off from the main reservoir; some are crushed and dammed up valleys, others are formed by sudden depressions of the land; the basin of the Königsee, at the foot of the Watzmann, is said to have arisen from the soaking through of salt water from the rock. The

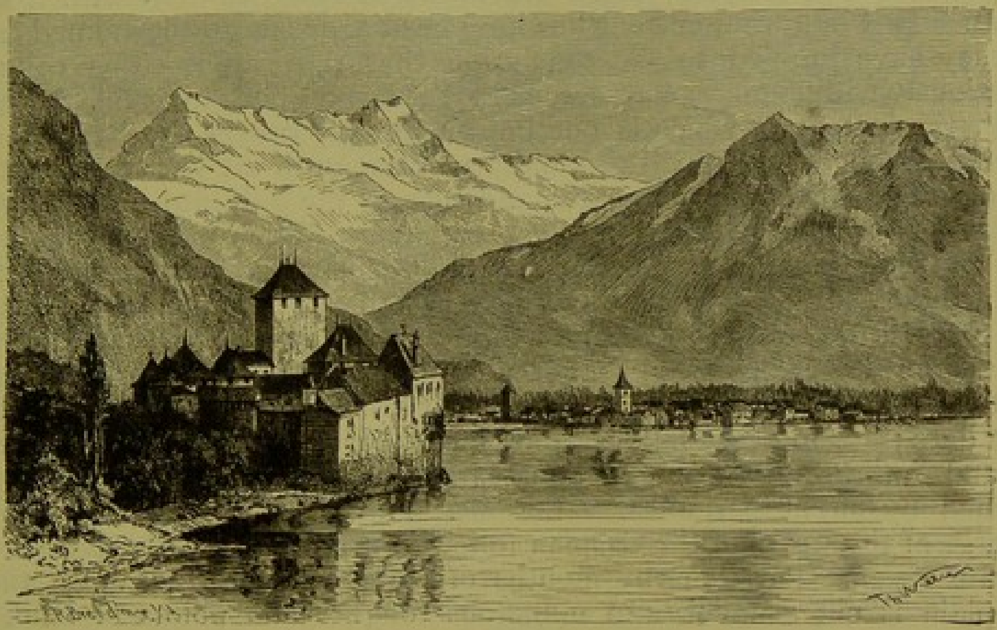
Victoria Nyanza, one of the largest lakes, probably owes its existence to a depression of the land. The same may be said of Lake Platte in Hungary, the only desert lake of central Europe, which must have been in prehistoric times of far greater size than at present, and have possessed a connection with the Danube. Rivers, as such, never form lake basins; on the contrary, they often fill them up and destroy them by pouring a quantity of *débris* into the sea. Geologically speaking, all lakes are of very recent formation, accumulations of water, which fill up their basin in course of time. The youngest of our mountains, such as the western Alps for instance, possess the greatest number of lakes, while older upheavals, such as the Pyrenees and the Caucasus, are strikingly poor in such reservoirs. The lakes through which rivers flow act as regulators; they receive the overplus of water when the river is high, and at low water they feed and support the lower part of the course. The rivers, moreover, deposit much of their mud and *débris* in the deep bed of the lake, and flow out of it all the purer and more transparent from their passage through the filtering reservoir. Of course these deposits,

The Königsee in the Bavarian Highlands.

accumulating through long ages, gradually choke up and destroy the lake. We find, therefore, that in countries whose general surface formation dates from a recent geological period there are a great number of lakes, because the rivers have not yet had time to fill them up. Thus Scandinavia at the present day is the very home and land of lakes and undeveloped rivers. There, as a general rule, no river has been able to hollow for itself a regular bed, and the little river lakes are placed in terraces one above the other, joined together by wild cataracts. It is the same thing in the lake plateau of Finland. The number of lakes scattered about the bare granite plains defies calculation; many, especially in the interior, have no outlet; others flow through narrow channels, and pour down in cascades of foam, but the time for the formation of a wide, deep, navigable river is not yet come.

The eastern point of the Lake of Geneva is being gradually filled up by the deposits carried down by the Rhone, which have already formed the low-lying land between Bex and Villeneuve. It is easy to see the Rhone at work, striving to thrust back the lake and extend the delta. The level of the lake is gradually lowered by these inroads upon its outlets, and the end is always found to be the total destruction of the reservoir. Many lakes, among which we may mention those of Parma, Piacenza, and Cremona, have disappeared in the course of centuries, and others have risen up in their stead. The great Neusiedel Lake in Austria, which flowed over an area of ninety-six square miles, has been dried up ever since the year 1866. The water was visible for the last time in the northern part of its bed during a strong west wind which blew in the middle of July in that year, and in the rainy season of the year 1870 the deepest places were filled with water, but only for a time. The lake moreover ran completely dry in the years 1693 and 1738.

For the present we may divide lakes into lowland and highland. The former generally cover the larger area, and are for the most part the relics of larger basins, which have lost by evaporation more water than they have received from rain and other sources. Lakes of this nature are generally very



THE LAKE OF GENEVA.

brackish, for it is the purer water which evaporates, and all foreign substances, salt of course being among the number, are left behind. The fate of every reservoir without an outlet is therefore to become in time a salt lake.

THE CASPIAN SEA.

There is no doubt that in a recent period of the earth's development the Caspian Sea was in communication with the Black Sea, and through the Black Sea with the ocean. Where, at the present day, the half-dried-up channel of the Manytsch is seen, flowed at one time an arm of the sea. Whether the ground slowly rose and so cut off the Caspian from the Black Sea, or whether the level of the latter was once considerably higher, may remain a disputed point; at any rate, from the moment when the Caspian Sea became a lake, the slow process of its disappearance from the earth set in. In the early time of its lake life the Caspian must have extended northward far beyond the Volga-Knie, near Sarepta; the line of the lake's level running nearly parallel to 40° N. lat. The salt soil of the steppes clearly betrays the bed of the former lake, and continues with a scarcely perceptible incline below the level of the present waters. Between Lake Elton and the actual shore of the Caspian Sea shells are found exactly like those found in the Kaspi Lake; and near Baku are similar ones, but of much stronger make. Now as the size of the shells corresponds with the amount of salt found within certain limits, it is clear that the quantity of salt in the Caspian has not increased. On the other hand, we know that numerous rivers carry down salt to the lake, and even the relatively small quantity found in the Volga becomes considerable by accumulation. We are forced therefore to conclude that there is some channel to carry off the salt of the Caspian. Such a channel is actually found, namely, in the Gulf of Karabuga, on the east coast, a bay 6,400 square miles in extent, which is joined to the lake only by a narrow shallow passage like a river. In this "black gulf" of Karabuga there is an unusual evaporation produced by the heat of the steppes. The level continually lowered by this evaporation is restored by a constant influx of water from the Caspian, which enters the seething caldron with a strong current. This inflowing current has long been a puzzle to the nomad tribes; and they have jumped to the conclusion that the gulf is either connected mysteriously with some distant sea, or that it has no bottom at all. A stratum of salt, the extent of which is not known, already covers the bottom of the Gulf of Karabuga, and it will gradually increase until the bar at the entrance prevents the further influx of water, and cuts off the gulf into an independent lake. At the present time it receives within its waters 350,000 tons of salt daily, and thus explains the reason that the Caspian Sea becomes no salter.

In June and July, when the Volga is highest, the level of the Caspian Lake rises a little; at other times, however, it is said to shew a gradual depression. This depression is not absolutely proved as yet; if it were, it would establish the fact that its separation from the ocean must be of very recent date; for in every lake without an outlet the alternation of evaporation and influx must speedily equate, and establish an equilibrium only disturbed by slight periodical variations. And it is more likely that the discharge of the water of the Caspian followed very closely upon its separation from the ocean. Between the mouths of the Kuma and the Volga the flat level plain is cut asunder into numerous tongues and points of land, with islands in front of them, and covered with low hills extending far into the interior of the steppes. If this range of low hills is compared to a fringed border, says Reclus, we shall find that the fringed lines extend fan-shaped to the north and to the south. They look like the ends of lines or spokes starting from a common centre, and the centre in this case is to be found in the depression of the Manytsch, on a rise in the ground from which the soil slopes down on both sides. This formation can scarcely be explained in any other way than by supposing that the Caspian in its rapid discharge broke up the soft, plastic soil into these spreading lines which astonish and perplex us at the present day. Exactly similar formations are found on the muddy brink of a pond when the floodgate is drawn up; there are the tongues of land, the low hills, and islands in minature. A remarkable circumstance, brought to light by the investigation of these hills near the Caspian Sea, is that they are all stratified, and that the various strata all appear as concentric curves. The clay strata are as it were the pith and core from which the sandier layers were deposited. This position of the strata is obviously the effect of the same currents which decided the present formation of the hills themselves; for it is clear that the layers of clay and sand thrust aside by the action of the water incline on each side toward the current which washes their base. Only in this way can the cupola form of the strata he explained.

The Caspian Sea may be divided into three parts. The southern and by far the deepest part is clearly bounded by the peninsula of Apscheron; the centre and widest part is more than 657 feet deep, while the northern is extremely shallow, and presents every appearance found in ordinary desert lakes.

To the east the Caspian Sea is divided from the Aral Lake by the plateau of Ust-Urt. Recent investigations prove that this plateau was once the bottom of the sea. The remains of the fauna of this former sea, as far as they can be determined, shew great resemblance to living forms in the Aral and Caspian lakes and in the Black Sea; and point to a remote flow of the sea which extended to China, and was afterwards interrupted toward the east by the outflow of the Caspian Sea. The mounds of salt on the plateau are other evidences of the presence of the sea in that place. The flat sandy shore of the Caspian lies of course below the level of the sea, and never became visible till the lake had disappeared. The water itself is so shallow in this part of the lake, that its greatest depth along the coast is only three yards and a quarter. The plateau of Ust-Urt sends no tributaries to the Caspian nor the Aral Lake; its highest ground is found round its outer boundaries, and the rain which falls within them flows along the hard solid clay of the steppes.

The Aral Lake—Decrease of the Waters of Western and Central Asia.

This lake is one of the most interesting in the world, when studied with respect to the history of our planet. It is situated about 256 feet higher than the surface of the Caspian Sea, and 165 feet above the level of the Black Sea. This fact must be taken into account when we are speculating as to its former connection with the Caspian and the Black Sea, and also as to its present isolation. It is apparently easy enough to explain every phase of the lake's existence and development by the regular rise and depression of the land by which it is surrounded. But such hypothetical movements appear to be contradicted by the construction of the eastern side of the Asiatic continent. The Aral Lake must be regarded as the great common reservoir of the waters of the Amu and the Syr, and the height of its level is in direct communication with the level of those rivers. Its waters contain but little salt. The shores of the lake present the appearance of an inhospitable desert, and its area is apparently decreasing; at least, the lake of Aibugir, once forming the south part of the Aral Lake, is now separated from it by a marshy peninsula overgrown with sedge. When, in ages long gone by, the river Amu, flowing in a bed whose traces can be still distinctly seen, turned toward the Caspian Sea, the Aral Lake must have been nothing but a marshy swamp, and indeed tradition records that the lake was once completely dry.

In the ninth century of our era the Amu flowed into the Caspian Sea; a fact of which the writings of Massudi and Abdul Ghasi leave no doubt. The desert waste, extending from the south-west of the Aral to the Caspian Sea, was then densely populated and carefully cultivated. Between the years 1530 and 1535 the waters of the river decreased, and disappeared at last from their western bed, putting an end to all agriculture. The reason of this decrease is not known; it may have arisen from the shutting out of the Amu from the lake by means of dams, but is more likely to have been effected by a general decrease of the waters of Western Asia.

It is indisputable that there has been in several places a general and natural drying up of the inland lakes of Upper Asia. If at the northern end of the desert of Gobi, the salt Dalai-Nor, near which the birds of passage collect in countless numbers before taking flight across the desert plain, and which is always frozen over until the end of March, is surrounded on all sides by salt plains, from which rise sandhills covered with grass and pasture land; and if this salt clay can be traced as far as Alaschan in the south, we have the proof that the lake extended far beyond its present limits. And the vast plain, covered with a thick crust of loose salt, stretching round Lob-Nor, in crossing which the traveller is choked by the whirling clouds of dust, and blinded by the white glare of the salt plains, shews that the lake has dwindled from the effect of the extraordinary evaporation of its waters, evidence borne out and strengthened by the salt heaps round the principal bed of the lake. Moreover, the desert land round the Ulungur Lake, and near the upper Irtysch, was probably at one time, at least in part, the bottom of an arm of the sea which extended as far as Saisan-Nor. The whole plain has a very slight incline toward the north-west, so that the Irtysch is extremely sluggish. A vault-shaped depression between the Ulungur Lake and the Irtysch still receives at high water an influx from the lake, which flows on to the river. The clayey soil of the eastern bank of the Ulungur is very easily washed away, and was greatly altered in the year 1872; and it is more than probable that a subterranean outlet exists between the Ulungur Lake and the Irtysch; such, at least, is the fact indicated by the sudden increase of the volume of water to the north-west of the river below the lake. The lake itself and its tributary, the Urungu, evidently once formed part of the Irtysch, which is only three Russian miles distant, by the low rocky ridge of Naryn-Kara. It was not until a later period that the Ulungur, like the Dalai-Nor, with the Kerlon, separated itself to become an independent water system. The eastern shore of the lake, known under the name of the Heights of Zirguntai, is a barren undulating plain bestrewn with shells, and covered with numerous patches of salt, which has every appearance of having been recently under water. A current tradition among the inhabitants tells us that the body of an Urjanchai, drowned in the Ulungur, rose to the surface of the Irtysch, and a very similar story obtains among the Kirgis of the Tchuskaly Lake, situated not far from the Irtysch in the sandy wastes of Bas-aigyr-kum, which also shew signs of having been submerged. The level plain of Zaidam, to the west of Koko-Nor, 8,850 feet above the sea level, is said by the people of the country to extend as far as Lob-Nor. The eastern side of this region is a mere salt marsh, overgrown with tall sedge, and was evidently at one time the bed of a vast inland sea. The same may be said of many other districts.

The disappearance of the miocene and post-miocene lakes is not in itself a proof of the decrease in the waters of Asia, but the drying up of the lakes and rivers of the desert points to that conclusion. The Sarafchan, on which Bokhara is built, can now only reach its mouth in the Amu-Darja once a year during the high water of the spring; at other times it spends itself and is choked in the sand before it can reach the Amu.

The river Emba barely reaches the Caspian Sea, and that with great difficulty.

The Ingis, which, when the post-pleiocene sea had reached its widest limits, emptied itself within the bed of the latter, was unable to follow the retreat of the sea as the Amu and Ushoi have done, but stopped short at Lake Tschalkar, which is evidently a fragment of the Aral Lake. Its volume of water is not sufficient to force its way beyond the lake, and hollow out a channel through the Karakoom into the Aral.

The same may be said of all the northern tributaries of the *Balkasch* lake, not one of which now flows into its waters. Only those flowing down from the mountains to the south, well fed rivers like the Ili, the Karatal, etc., manage to reach the Balkasch. And the great Hamun Lake, on the south-western boundaries of Afghanistan, which is only the fragment of a far larger lake, is now partially dried up. The Hilmend, one of the largest rivers of Afghanistan, rising to the south-west of Cabul, dries up during the lower part of its course through the desert, and cannot reach the Hamun marsh; and its tributary, the Lora, only brings its watery contribution at high water in spring, and at other times is lost in the sand before it can reach the river.

It seems indeed as if in the dry air of central Asia the loss of water by evaporation is not compensated by the atmospheric rainfall, and that the exchange slowly inclines toward the side of loss. We are therefore inclined to think that the drying up of the Ushoi is principally caused by the general desiccation of central Asia, and we do not think it possible that its exhausted bed can be again transformed into a watery highway.

THE DEAD SEA.

The Dead Sea (Bahr-Lut) is without doubt one of the most remarkable inland seas in the world. From the earliest times spoken of in the Holy Scriptures the lake appears to us shrouded in the veil of mystery and wonder; but, in spite of numerous descriptions from the pens of eye-witnesses, no scientific information concerning its peculiar characteristics was obtained until the beginning of the second half of the present century. It is the deepest known depression existing on the surface of the globe; for its surface of 368 square miles in extent lies 1,314 feet below the level of the sea. Its waters cover the southern part of the deep hollow which separates the Holy Land from the eastern highlands of the desert; and into it flows the scanty water supply of the river Jordan. The first sight of the Dead Sea recalls the centre of some volcanic district, and travellers have spoken of fragments of lava and other tokens of subterranean fires, but no sign of volcanic action can be perceived in the whole region encircling the lake. It is more likely that the action which has produced the grand effects is due to the erosive force of water instead of fire. The former reign of water is shewn by the steep washed-out slopes, the mounds of stones and *débris*, and the vast banks of chalk. In an earlier phase of the earth's development the sea covered the valley of the Jordan as far as the foot of Antilebanon, and extended southward toward the Red Sea, without, however, coming into contact with its waters. Numerous powerful watercourses excavated valleys and ravines near the Chor, and have left traces in the slender threads of water which appear periodically at the present time. With the decrease of its tributaries, caused by climatic influences, the surface of the sea was also reduced to its present limits by evaporation. More recently the southern parts of the lake, which are so shallow as to be almost fordable on foot at low water, have widened in places; and it is here that the Siddim mentioned in the Holy Scriptures probably stood. We have in the Dead Sea an hydrometer or measure of the atmospheric rainfall. The variations of level are now indicated by the driftwood which, partly coated with salt, encircles the shore. The amount of salt found in the Dead Sea, and the presence of asphalt within it, deserve special consideration. In the remotest ages Egypt drew from the Dead Sea the asphalt used for the embalming of the dead. Diodorus and Strabo both record that from time to time bubbles of asphalt, like the bubbles of a boiling caldron, rose on the surface of the sea, and were fished up by the inhabitants. Even now, especially after an earthquake, similar masses of asphalt rise, and are gathered by the Arabs. This appearance of asphalt is thought to be occasioned by the sudden rise of bitumen at the bottom of the sea. The greasy feeling left by the waters of the lake upon the hand, the presence of organic matter in the salt water, which smells of bitumen, and has been detected by chemical analysis, and the greasy fog which, according to the testimony of many visitors, often hangs over the waters, may perhaps owe their existence to some constant submarine flow of earthy oil.

The blue waters of the Dead Sea contain no fish, but its banks are covered with brush and thicket, and the song of the lark is sometimes heard amid the stillness of the desolate scene.

A remarkable pendant to the Bahr-Lut is seen in the Dead Sea of North America, the Great Salt Lake of Utah. That, too, had once a much greater area than it now covers, and at the present day its depth is by no means great.

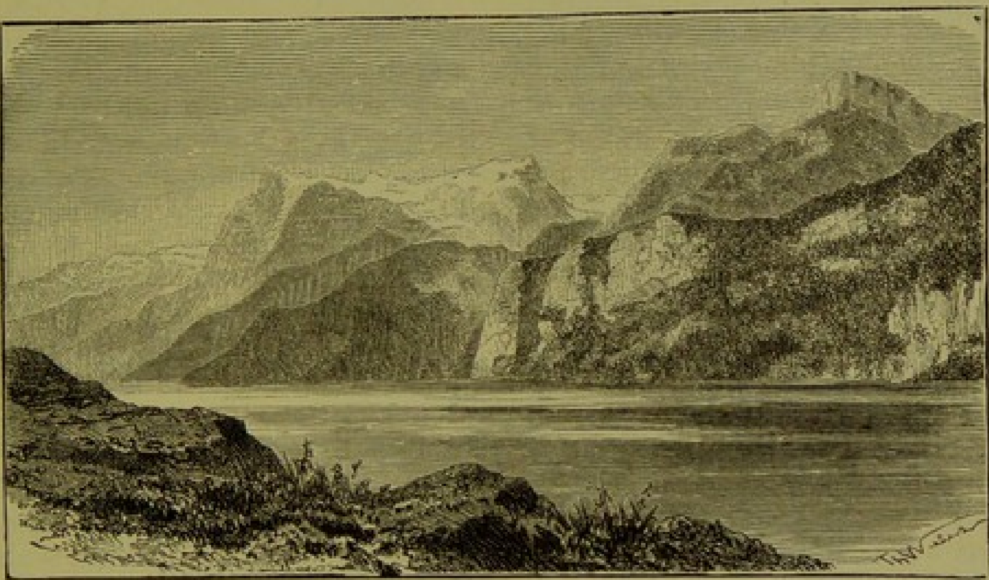
Mountain Tarns—The Swiss Lakes.

The mountain and highland lakes are generally small; sometimes of great depth, but occasionally flat monotonous pools, with marshy banks. In the Alpine regions we find them represented in every degree of size, or rather of littleness. They generally appear as small isolated tarns, filled almost entirely by the glacier waters, and of crystalline purity. For a considerable part of the year they are frozen over, and in many of them neither the source nor the outlet of their waters is known. The largest mountain lake is Lake Titicaca in South America, which has an area of 2,400 square miles, and lies 12,846 feet above the level of the sea. It is 2,100 feet deep, has no outlet toward the sea, and is gradually decreasing in size; for the ancient city of the Incas, Tia-Huanacu, which was once close to its brink, is now miles away, and high above its level.

The Swiss lakes, beloved of all travellers for their varied beauties, are less attractive to the geographer who wishes to study their origin and development. These lakes baffled every suggestion of science so long as it was endeavoured to explain the origin of all by the same reason, whether the cause was supposed to be the action of the upheaval of land or the erosion of water-floods and glaciers. The truth is that each lake is a separate personality, as it has been well expressed, and has its own history and its own origin. There are lakes which have been formed by the cleaving asunder of the mountains, others which owe their existence to the washing out or excavation of the rock, others created by the damming-up of valleys, and others which are the result of several of these reasons combined. One arbitrary division classifies the lakes into orographic and excavated basins. The orographic lakes are those which are produced by the primeval configuration of the earth, and are generally found in Switzerland proper. The lakes formed by excavation are met with in the outlying districts of the country, and comprise Lakes Constance, Neuenberg, Murten, and Biel, and the lakes of the Jura valleys.

The Lake of Geneva is orographic between Villeneuve and Vevey, and between Vevey and Geneva it is a pure *erosion* lake. The orographic lakes have been variously subdivided into flat lakes found in wide valleys, deep lakes formed by the rending open of mountains into rocky gorges, and a medium kind, or rather a combination of the two former classes, which owes its beautiful scenery to its participation in the characteristics of both. The ages of these lakes depend entirely upon the manner of their origin. The orographic lakes were created of course at the same moment that the Alps received their present form; but the appearance of the excavated or erosion lakes points to a second phase of development, which is more or less directly dependent on the former phase. Geologists have proved that the comparatively modest area covered by the glaciers of Switzerland stretched out in long distant ages to such wide limits that the whole country was sheathed like

Greenland of to-day in complete armour of solid ice. At that time the glaciers extended as far as the parallel range of the Jura, and scattered over Switzerland the alpine blocks which we find there at this day. The glacier currents met by the opposing rampart of the Jura rose there to the enormous height of 4,275 feet, and pressed down the valley of the Rhone as far as Lyon. The formation of the lakes of Switzerland is ascribed to this activity of the moving glaciers which hollowed out their beds. This fanciful supposition, although supported by such names as Ramsay, Peschel, and Tyndall, rests upon such an erroneous conception that we are inclined to agree with Rütimeyer, who says that under a covering of glacier ice the formation and growth of the valleys would come altogether to an end. On a closer investigation of the Alpine valleys we find that in many cases they are decidedly older than the glaciers, and therefore must have existed before them, and could not have been created by them. Now as during the ice period blocks of the Alps were carried across to the Jura, the lakes across which they were rolled must have lain buried beneath a deep crust of ice, and could not have



Scene on the Lake of Lucerne.

become lakes until the retreat of the glaciers. If, however, we look upon the southern slopes of the Alps, and examine the mountain lakes of Upper Italy, the Lago Maggiore, Como, and the wide lake of Garda, and the various smaller lakes near them, we meet with a totally different formation of the lake bed. This lovely lake land, beautiful with every charm of rich vegetation, and lighted by unclouded sunshine, was once the scene of desolate morasses, and beneath their present smiling aspect lies hidden the chaotic wreck scattered by old-world glaciers. But this substratum of rock, sand, and *débris* does not extend over the Lombard plain to the Apennines, but has a sharply defined limit, beyond which it is replaced by the rich soil of the valley of the Po. We are forced, therefore, to conclude that there existed here in the time of the great glacial period some obstacle which the glaciers were unable to surmount. This obstacle was nothing less than the old-world Lombard Sea of the pleiocene period, whose waters washed the base of the Alps and that of the Apennines, and whose existence has been demonstrated by Desor and Stoppani. Upon this supposition we are able to explain the wonderful gradations which strike the traveller as he approaches the marshy district above Monza on his way from Milan, and which extend right and left like a terraced shore-line. Here, in all probability, was the boundary of the Lombard Sea at the time of the retreat of the glaciers, when the moraine landscape was already formed in its whole extent. The Italian lakes were at that time bays of the great Lombard Sea, a fact shewn by their great depth, which extends far below that of the Adriatic Gulf. As the glaciers forced their way forward, this bed was gradually filled with ice, and the moraine landscape to the south was formed. The cause of the disappearance of the Lombard Sea is said to be the vast deposits of glacier mud brought down to it; and there is nothing overstrained in this explanation, for we know that the Rhine glacier alone by its deposits has formed the Wetterau. But, be that as it may, it is in any case clear that after the retreat of the glaciers the inroads of the former Lombard Sea formed lake basins, whose overflowing waters found an outlet towards the south.

Marshes and Swamps.

When the water, slowly retreating, stagnates, and becomes mixed with earth and vegetable remains, producing a soft boggy surface, the formation of marshland has begun. The transition from lake to swamp is a gradual one. Many an accumulation of water appears now as a lake, now as a swamp, according to the time of the year; many a lake is seen from afar as a true lake, clear and bright, in the midst of an impenetrable morass, a perfect marsh lake. Every lake as it disappears is changed, first to a swamp, and then to meadow land. Marshes are often found along low river shores; sometimes also the sea coast is outlined by marshy swamps, and sometimes we find them on heights far above the sea level.

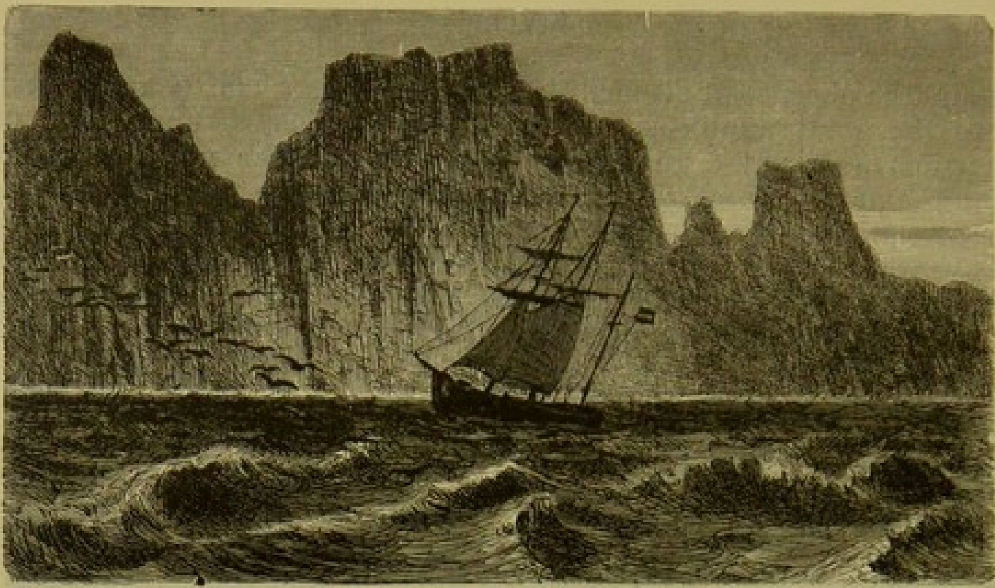
The most extensive swamps are found in tropical regions; from the bushy, overgrown land of Terai, on the southern side of the Himalayas, the home of deadly fever, and the vast girdle of swamp and marsh round the northern boundary of the highlands of Abyssinia, to the Dismal Swamp between North Carolina and Virginia, which resembles a vast mass of decaying mould, and encloses a lake of horrid red-brown water. The peninsula of Florida is also full of large fever-breeding swamps, and its largest river, the St. John, flows from the Cyprus swamp. In the same peninsula are found the so-called "wet deserts" of the Everglades, with their oasis-like islets scattered over them in countless numbers. Wherever the marshland of Florida can be cleared and drained, it has been found to be extremely rich and fertile. But the swamps on the lower course of the Mississippi are inaccessible to men, a paradise of alligators, coral snakes, and swarms of venomous insects. The deltas of many tropical rivers form extensive swamps. We will only mention the vast marshland at the delta of the Niger, intersected by numberless sluggish streamlets, and overgrown with dense forests, wholly inaccessible to Europeans, because of the deadly, pestilential vapour exhaled from them. Large swamps are met with also in the temperate zones. The low land between the Bug, the Dwina, the Dnieper, and the Dniester, in West Russia, is filled by swamps, and over a space of nearly thirty-two thousand square miles forest and marsh contend for the victory. Desolate and boggy are the flat coast lands of Western Italy, between the Arno and the Gulf of Gaeta. The most dreaded of them all are the Pontine marshes between the Volscian Hills and the Tuscan Maremma. These unhealthy solitudes have been formed since the decay of the Roman Empire and civilization, were created by the great luxuriance of vegetable

FIORD IN FRANCIS-JOSEPH LAND.

growth and the absence of all facilities for drainage. The German marshes, owing to the great admixture of vegetable remains, assume more of the character of moorland. In the Netherlands and the north-west part of Germany the moors are of great extent, and impart to the landscape an air of utter desolation. The marshes of East Friesland, Holland, and Oldenburg extend over the surface of many square miles, with no elevation of their dreary level, except the long coarse grass swaying in the wind. During the greater part of the year the high marshes, so called for not yet having been worked

Fever Marsh in Florida.

for turf, are absolutely impassable. Only those who have been from childhood familiar with their paths, formed by raised clods of solid earth, which the traveller crosses by springing from one to another, dare make their way across them; a stranger runs great risk of sinking in the treacherous bog. No road can be laid down upon the shaking soil; laden vehicles can only cross it when it is covered with a coat of hard ice and frozen snow. It is the land of floating islands; the sluggish marsh streams tear up acres of turf, and carry them, with everything found upon them, far out toward the sea, until some obstacle arrests their course, and the island becomes one again with the dry, or rather with the quaking, land.



THE NORTH CAPE.

CHAPTER V.

THE LAND.

FORMATION OF CONTINENTS.

LIKE an immense uplifted plain the continents tower above the abysses of the ocean. They rest on mighty sockets of more than three miles deep, which form the base on which the mountains rise and the low plains spread abroad above the level of the sea. This upheaval of land above the depths of the water shows itself mostly in large masses like those of the continents, and seems to be so universal a law of the formation of our earth's surface, that even the majority of our islands are of continental origin. Many island regions betray their original connection with the mainland by the shallowness of the sea which surrounds them. No one can doubt, for instance, that the British Isles are a fragment torn from the continent of Europe, when he considers the shape and formation of the submarine plateau on which they rest, and this conclusion is fully borne out by the recent geological and palæontological investigations of modern times. But, although we have learnt to expect this concentration of land into compact masses of great size as the general law of the earth's formation, we have no accurate scientific information as to the cause which drives it upwards from the bed of the ocean. The only certainty to which scientific men claim to have attained is that the process is very closely connected with the formation of the crust and the gradual cooling down of the globe. This process places the origin of continents in a long-past age of mythical antiquity, a period of which we know nothing, except that while it lasted the earth contracted during the process of cooling, leaving elevations and depressions which in their general lines have been decisive for every age to come. The general outlines of the continents then traced remain the same to this day, and upon them all subsequent divisions and upheavals have taken place. In saying this we do not mean to deny that during the long unknown period of the earth's development there have not been great changes in the horizontal and vertical distribution of the mainland; but we do mean to assert emphatically that the general outlines of the continental masses then established, and shewn in the crowding together of the land in the old world in contradistinction to America, took place in the first ages of the world. Were we to go farther, and to say that the present division of the continents belonged, even in roughest outline, to the same period of the earth's history, we should find ourselves at war with the most clearly proved facts of geology; for the deposits left by former seas upon large tracts of our present continents shew that the ocean waves once flowed where cornfields are now growing, and stranger still are the signs which tell of wide stretches of land now submerged beneath the sea.

The rendings of the earth's crust during the long process of cooling down have naturally engaged the attention of modern science, and their course and development have been characterised as follows. In consequence of the flattening of the poles, the adjoining arctic regions, being violently compressed, became harder and more unyielding than the rest of the earth's surface. The largest fissures could not therefore be made through the poles themselves, but would be found on the edge of the flattened zones at about the fifty-fifth degree of north and south latitude. One principal crack was made between these limits, and another vertical one opened from the former; a third cleft appeared in the direction of the present Atlantic Ocean. Manifold changes of form may have taken place since then, but by the configuration of the continental masses at the present day we may trace indications of their primeval "break up" in the earliest ages.

It has been thought that the solid land has gained in extent since the tertiary period, by stretching out to the north and west; while in the south and east of the present dry land lie large spaces of lost continents. This idea receives some support by the great number of islands found along the south-east side of the continents, when compared with the north and western sides.

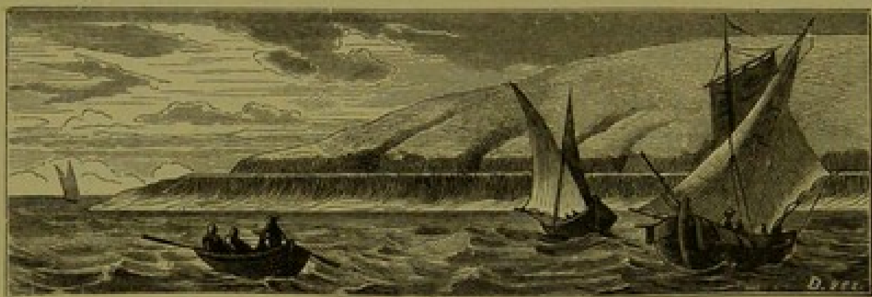
RISE AND DEPRESSION OF THE COAST.

Whatever may have been the process with respect to the upheaval and depression of the mainland within certain definite limits, we are in any case forced to assume that the changes must have been slow in accomplishing their work, and we are confirmed in our assertion by the slow processes of change going on in the continents on which we live, the effects of which are becoming visible before our very eyes. We are not now speaking of those changes brought to pass by floods and earthquakes, but of the various local changes produced by the alteration of the coast line with respect to the level of the sea.

Scandinavia presents us with the best example of this kind of change. No great interest was felt in this process until the year 1743, when Celsius published his famous treatise on the "Diminution of the Waters of the Baltic and the adjoining Ocean." Only in 1802 Playfair started the theory that the alteration was due not so much to a sinking of the sea level as to a rise of the land above the surface of the water. It was found that this rise of the land was very unequal in degree, even in places comparatively near together; that in the northern districts of the peninsula there is an oscillating uprising of the land; that between Kalmar and Carlskrona scarcely any alteration of level is perceptible; and that at Schonen, the most southerly province of Sweden, the land has been slowly sinking for centuries past.

The fact of this depression of the lower part of Sweden is the more remarkable because in earlier—partly indeed even in historic—times the process was exactly contrary. Many circumstances indicate that the south point of Sweden was once an island lying in the arms of the sea, and extending from the Gulf of Bothnia to the Kattegat. Even at the present day the remains of arctic fauna, once living in the place, are found in the depths of the Swedish seas. And the remains of the flora found in the Danish isles indicate no less clearly the prevalence of a former arctic climate, and its softening down to a milder temperature in the course of time. In old graves, and deep below the turf land of the moors, are found coal remains of pine and fir trees. After these came large forests of oak, which were in their turn succeeded by the noble beech woods found there at the present day. The connection once existing between the Baltic and the White Sea is embalmed in the language of the people, for the word *baltas* is an old Livonian word meaning *white*. The origin of the word *Scandinavia* itself, which was originally applied to the southern point of Sweden, the Schonen of to-day, simply means "the bent or crooked island." This meaning is contained in the word *Skandin;* and the Goths, who did not know the language, added from their own tongue *Avi*, which also means island.

If we turn from the flat coast of Sweden to the steep, rain-washed,



SHORE LINES BETWEEN VANG AND SKAARLIODDEN.

weather-beaten cliffs of Norway, we see the result of long uprising of the earth visibly before us. Remains of sea animals are found in the rocks at least 495 feet above the present level of the sea; and many a horizontal cleft in the face of the precipice bears the name "old shore line."

Only recently have the latter been thoroughly investigated, with the following result:— These shore lines are traced with more or less distinctness across the rocky walls, and cannot be distinguished in every light. When one is close to them, they present the impression of a road laid down horizontally by blasting the rock—an impression strengthened by a still closer contact. This is true of the shore lines in their best state of preservation; in other places they are not easily distinguished when seen from above, and not until the traveller has looked at them again from below, and fixed the locality in his memory, is he able to confirm it upon a closer inspection; for that which, seen from below, looked like an unbroken continuous line, now appears in fragments, and only on certain rocky projections can the level road, with its wall of cliff at the back, be recognized. And even in these projections the regularity is often disturbed by the fall of the rocky wall at the back of the heap of *débris* it brings down with it; and in other places by bushes and growth of hardy shrubs; so that a casual observer would detect nothing beyond the ordinary decay of any weather-worn rock. But upon the very next projection traces of the same old road are found at an exactly corresponding level above the surface of the sea. And more wonderful still is the clearness of the numerous shore lines found upon the northern coast. On this side of the country circumstances have favoured their preservation; and the lines are so unbroken and so regular, that were it not for the obvious absurdity of the idea, one would be tempted to pronounce them the result of artificial plans laid down by man. The two illustrations afford good examples of these interesting shore lines; the first view shews only a single line, and the second, taken from a greater distance, represents two parallel shore lines, and brings before our eyes a sight often seen in the North—namely, the lines following the curve of the shore without any break of their regularity. It often happens that when the rocky coast is interrupted by the opening of a valley, the connection between the lines is established by one or more terraces running in the same direction. The lines are generally approached by steep descents, and some indeed are absolutely inaccessible. But sometimes, as is shewn in section drawings of the locality, there is a gentler incline from the outer edge of the horizontal road downward, and in that case terraces are often found below the line itself. The origin of these shore lines is ascribed to the erosive power of the sea; and it follows, as a matter of course, that by the uprising of the land to its present position they are no longer subject to this influence.

Along the Prussian shore of the Baltic there are unmistakable signs of a depression of the land, shewn by sunken turf moors and the advance of the sea waves over certain shallow reaches. It is positively asserted that the Haffs of the Baltic are by no means isolated arms of the sea; but lost tracts of land submerged by the sinking of the coast. They somewhat resemble the strand waters of the eastern side of the United States of America. Thus the Prussian Nehrungen and the islands of Usedom and Wollin are so far from being the boundaries of fresh land added to the continent, that they are merely the remains of the former coast, which have so far resisted the work of destruction, but, owing to the continued depression of the coast, can no longer escape their doom.

In the Danish islands an alternate uprising and depression is to be assumed.

Double Shore Lines near Grötnes.

The island world of Denmark was created by a depression of the land, and then the gentle rise which succeeded it strove to reunite the smaller to the larger islands, and to smoothe down the inequalities of the coast line. This rise, however, did not last long enough to equalize the manifold clefts and fissures split open by the preceding depression, and so we find nothing but long fingers of land stretching out far into the sea, and broken up by fiords and channels to testify to its exertions. Several elevated points near Ljim Fiord are still called Holme, and so prove their former insularity.

A submersion indicated by the presence of submarine woods and moors is found to have taken place along the western coast of Schleswig-Holstein. They are found not only below the marshy soil of the coast, but also in the so-called "Flats" between the Frisian islands and the coast. They are found reaching from Husum to the mouth of the Elbe. The trees are still partly rooted in the ground, so that any mere drifting from another place is out of the question. Near Oland the trees are tolerably near the surface of the water; between Romoe and the mainland they are fourteen feet, and near Friedrichstadt they are as much as thirty feet below the average water-mark. The fact that this submersion took place at a time when the land was inhabited is proved by the discovery of a grave in a sunken beech wood near Husum, and by fragments of earthenware near Krempe in Holstein.

Along the coasts of Holland and Friesland the sea during the period between 1531 and 1591 carried away 5,800 acres of land, and between 1591 and 1647, 1,800. Between 1647 and 1687, about 1,000 acres were lost, and 1,400 between 1687 and 1740. During the restoration of the Cathedral at Ravenna, in the year 1731, the remains of an old stone pavement were found four feet and a half below the one then in existence, and far below the highest water-mark of that time. A pavement was also discovered in the Piazza di San Marco in 1722, which was three feet and a half below the surface of the Gulf of Venice. In the excavations made in the island of St. George, in the lagoons, relics of a former staircase with sunken piles and stakes were found, and near to these remains lay the foundation stone bearing the name of the architect, and pointing back to a time long before the days of the Roman empire.

The ruins of the Temple of Serapis, near Pozzuoli, are often brought forward as evidences of the alternate rise and sinking of the ground in that place. The columns of the temple, once so beautifully adorned in the days of Alexander Severus, A.D. 235, and now eaten away by moluscs, shew the advance and subsequent retreat of the waves. It is clear that a depression did take place, from the fact that a passage is shewn in the Apocrypha of SS. Peter and Paul, which dates from the ninth century, where the submersion is ascribed to a miracle wrought by St. Paul. The principal rise seems to have taken place in the sixteenth century, with the appearance of the Monte Nuovo, and a depression recommenced. In 1807, Nicolini was able to draw inside the temple without being inconvenienced by the water; but in 1823 the waves had reached the place, and he was obliged to lay down a road of stones to stand upon. From this time until 1838 he instituted a series of observations which established a yearly average depression of one-fifth of an inch. In 1838 the sinking progressed so rapidly that fishes were caught in places which were dry land in 1807. Lyall observed already in 1828 that not only the Temple of Serapis, but the whole coast, was losing ground. Fishermen in Pozzuoli declared that within their memory the land had lost ten yards. The temples of Neptune and of the Nymphs, to the north-west of the Temple of Serapis, are now nearly six feet under water. Two Roman roads are also submerged, one of which, which leads from Pozzuoli to the Lake Lucrine, is still partially visible. There is, perhaps, no other place upon the earth where the rise and fall of the land have been so frequent and so extensive as near Pozzuoli.

When we examine a sea chart of the Mediterranean, the shallowness of the sea shews that in an earlier geological epoch Africa and Europe must have been much nearer together than they are at the present day; and, retreating a step backward up the course of ages, that they must have formed but one continent. It is probable that this state of things existed at a time when the present south coast of the eastern part of the Mediterranean was uplifted, and extended far toward the south, over a great part of the present desert of Sahara.

A geological map would confirm us in our suppositions. For the eocene formations which appear along the north coast of Africa, and especially in Tunis, are also found on the coast of the island of Sicily; while the southern and south-western parts of the same island shew the latest tertiary stratifications. They encircle also the coast of the great Syrtis, where the Mediterranean, even at this day, presses farthest to the south, and where, probably, lay the last shore which the sea, once flowing over part of the desert of Sahara, washed with its waves. The well-known terraces, known to every geologist, indicate slow uprisings of the land, alternating with long periods of rest. These terraces were found in the ascent to Tolmita, the Ptolomais of the ancients, where they are separated by wide level plains.

As if to remind us that geological periods, when measured by years, are of immense duration, we find that in the course of many thousand years the coasts of Sicily and Tunis are again rising, islands becoming joined to the mainland, and the sea gradually retreating from the shore. The old harbours of Carthage, Utica, and Biserta have long been dry; nay, the port of Farina, near Utica, was navigable even at the beginning of the present century, and is now too shallow to afford passage to the smallest ships.

South America offers great facilities for the study of the alteration of the coast land; next to Scandinavia, it may be called the classic land of such investigations since the year 1831, when Darwin published his series of observations. We find first that the Pacific and Atlantic coasts of the southern part of South America shew a contrary procedure. The eastern shores of Patagonia and the southern point of America, from which the Falkland Islands were separated at some long distant period, are both sinking. The Pacific coasts, from the island of Chiloe onwards, is slowly rising, subject, however, to temporary sudden risings, occasioned by earthquakes, which must not be confounded with the slow processes which we are considering. Round many promontories, and at the mouths of several valleys which break through the mountain ranges of the coasts, we find old shore terraces strewn with relics of shells and sea animals, such as still live in the adjoining bays. In some cases these shells are found deeply embedded in the earth. These terraces, separated one from the other by steep descents, look like steps of a giant's staircase, and shew that the coast must have risen, not all at once, but with long intervals of rest. On the hills of the island of Chiloe shells were discovered some 348 feet above the level of the sea. To the north of Conception Island are several shore lines cut in the rock during the present period, at the height of from 429 to 987 feet. To the north of this town the lines sink again; near Coquimbo they are scarcely more than 330 feet high, and on the boundaries of Bolivia only from 195 to 246 feet above the level of the sea. The rise of the rocky coast is most perceptible in those districts which are in the same parallel of latitude as the highest point of the chain of the Andes, Aconcagua, and Maypu. This proves that those high peaks shew, as it were, the axis of elevation of the uplifted crust of the earth, and that they themselves rise much more rapidly than the plateaus and coasts below them. In Chili, as in Norway, the terraces which enclose former gulfs of the sea or land valleys are not strictly horizontal. They rise slightly, following the curve of the mountain, and become higher in proportion to their distance from the coast. The uplifting force acts, therefore, with greater energy under the Chilian Andes than under the rocky stone of the adjoining coast.

The fact that a coast along which there are found volcanoes in a state of activity is in a state of upheaval is true over all the world; but the fact must not be stated conversely, since coasts rise where there are no volcanoes in existence. It is found, however, that active volcanoes do not exist where the coast is in a state of gradual depression. The clearest evidence of this statement is found in the great depression basin of the South Pacific, although we consider that it amounts by no means to a great natural law, but stands in the same relation to law as do the rules of grammar. Neither the age of the land nor the construction of the coast bears any demonstrable relation to the rise and depression of which we speak. We have not yet been taught the guiding law which will explain the confusion of rising and sinking continents from any general point of view, nor that which regulates the slighter elevation and submersion of the coast lines. It is certainly no action of chemical force, such as appears in the decomposition and transformation of rock and stone, to which we may ascribe these secular movements; nor are they due to the action of subterranean volcanic forces. We find ourselves confronted by an unsolved riddle, which we have not as yet been permitted to read. It is not within our province to attempt to lift the veil hanging over the secret, but we venture to draw attention to a circumstance which does not appear to have attracted as much notice as it deserves. We can only follow the processes of the solid crust of the earth as they exist along the coasts, but of course the same processes must be going on within the centre of the continents. Now, if we see that, in spite of these alterations of position in the interior of our continents, no change in the network of intersecting rivers is produced, we are led to conclude that the continents, generally speaking, are raised or depressed in a compact mass parallel to itself. This conclusion is, in its essential parts, suggested by all our former observations. But it is impossible to conceive of any force great enough for the uplifting of whole continents in a slow, gradual rise, continued through thousands of years; and we ask ourselves whether these upheavals and depressions may not be for the most part only apparent movements caused by alterations of level in the surrounding oceans. If the objection is made that such alterations of the sea level must necessarily be universal, we answer that oscillations of long continuance, limited to a relatively restricted portion of the earth's surface, are quite possible. And such oscillations as these may be accounted for by slow displacements of large masses within the interior of the earth.

This hypothesis finds considerable support in the general proportions of level in the North German plain. A stratum of great depth, in some places amounting to hundreds of yards, rests upon this plain, and is made up of gravel, sand, and clay, with embedded rocks, which can be proved to be of Scandinavian origin. These wandering masses of stone, starting from the central point of the Scandinavian mountain range, were carried by icebergs to North Germany and Holland. Also the wide plains of Russia are strewn with rocks whose primeval home was found in Finland. All this goes to shew that the North German plain once lay beneath the waves of the sea, and that later it rose to its present height above the surface. One circumstance, however, is passed over by this hypothesis, namely, the regular horizontal form assumed by the plain in all its vast extent. Standing upon it, objects are seen to disappear below the curve of its horizon, as they are lost to sight upon the plain of the ocean. No one can doubt that the plain once formed the bed of the ocean, but it seems equally obvious that an area of thousands of square miles cannot have been uplifted parallel with itself. Such an exertion of force is inconceivable. But if, owing to the sedimentary deposits, the bottom of the sea was once perfectly level, it would retain this formation when the waters slowly sank and allowed the dry land to appear. It is, therefore, our opinion that during the diluvial period the level of the sea stood considerably higher, and has sunk in the process of time.

CONSTRUCTION OF THE COASTS—FIORDS—DUNES.

The seaward boundary of the mainland is the battle-field on which the warring elements wage their eternal strife *à outrance.* Where the land runs out flat and shallow toward the sea, the ocean casts up sand and shingle, and the wind blows them up into dykes and ridges, which close in the land as with a rampart. On high and rocky coasts the softer stone is washed by the surge, and carried away, leaving behind strange fantastic forms, columns, caves, and projecting ledges of the harder rock. On the jagged cliffs of Heligoland we see the effects of the struggle in many a wild fantastic outline fashioned by the waves; and that which we know is in this case the work of long ages takes place on other coasts in the short space of one man's life. Within the last few years the coast of Suffolk has been thrust back for about eighteen yards, and the depth of the sea has increased to such a degree that a frigate can sail without danger where half a century ago the corn stood in the fields. And in the Halligen many a man lives to be older than the soil on which he now stands. To form an idea of the destructive force exerted by the ocean waves, they should be watched at their work some stormy day along

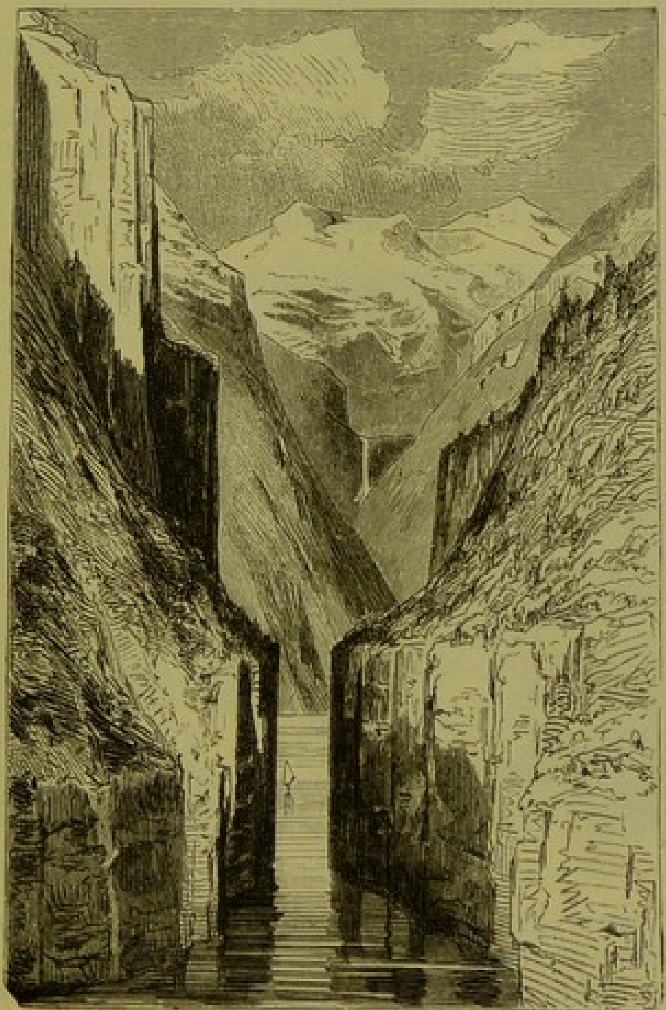
Action of the Waves against the Rocks.

the coast of Havre or Dieppe. The army of the waves, drawn up in rank and file, and crested with the white plumes of the surf, advances in rapid march to the attack. Spurred onward by wind and tide and current, it dashes across the sand and sunken reef to the base of the solid rock. Its assault thrills through the giant mass, which shudders at the shock, and gives back the echoing thunder from its cavernous recesses. Hurled with terrific force into every gaping crevice, the invading forces drag out their booty of stone and broken fragments of the cliff, wash away the soft particles of clay and limestone, loosen the solid strata, tear down large blocks, stamping and grinding them to pieces in the wild retreat, and carrying them back to the ocean across the whitened strand with the triumphant thunder of the surge. In the turbid confusion that boils and seethes close to the shore, the work of havoc is but half revealed; but look seaward, and you will find that the floods are dark and muddy, with the wreck far out toward the horizon. A magnificent example of the action of the waves may be seen upon the coast of Norway. Here we can trace every phase of the process from the vantage ground of the steep overhanging rocks, the black forbidding walls of cliff against which the pitiless breakers dash every ship that comes too near. There are the gates of rock, the cliffs and islands that form a dangerous fringe round the desolate shore, where the encircling waters swarm with fish. The most remarkable formations on this coast are the deep, narrow, vertical arms, or rather *fingers* of the sea, known as fiords. Most of them are deeper inland than at their entrance, many being even deeper than the sea from which they come. Some of these narrow rocky chasms are seldom reached by a ray of sunlight; the traveller looks down from some jutting ledge of rock into the gloomy depths, hearing the roar of the waves and the dash of many a waterfall far below him.

This fiord formation is by no means restricted to the Norwegian coast; it is found also in Spitzbergen, on the shores of Greenland, on the southern coast of South America, in all high latitudes—in short, wherever the coast is precipitous and the rainfall considerable. These three conditions, taken in conjunction with the important fact of the fiords reaching down below the bed of the sea, furnish us with valuable hints as to their origin. We must suppose that the fiords of Norway are chasms formed by the upheaval of the land, from the strain of the curved lines of the strata which split asunder not only in one and the same direction, but corresponding to the terrace-like formation of the land into several clefts and fissures intersecting each other, so that Norway is actually split up into groups of fragments separated by open chasms. The position of the valleys, fiords, and waters is intimately connected with the dividing lines of these fragmentary chasms. As we are forced to believe that similar chasms and breakages must have occurred wherever the land was uplifted, and as they only preserve their integrity in the higher latitudes, we are led to look upon the poles as the conserving element. And as a matter of fact this conserving power is exerted by the glaciers. For the chasm or fiord filled up by glaciers is naturally protected from being torn and filled by mud or rocky *débris*. In the earlier ages of our earth, known as the glacial period, the whole of Norway was completely covered by glacier fields which cased it in their impenetrable armour, until, upon the melting and disappearance of these vast masses of ice, the primeval chasms and breakages reappeared. At the present day the glacial action is still seen in Greenland, which lies frozen beneath its stretches of hard ice, and we may predict with certainty that when the glaciers melt from its surface, the fiords now filled and covered beneath them will be brought to light. We see, then, that the glaciers are the conserving element which preserve the fiords, but which have no hand in their creation. And from the moment of the disappearance of the glaciers the work of disintegrations set in within the fiords. The air and wind and rain attack them from above, storm and sea assail them from beneath, the mountain torrents bury their sharp outlines beneath their load of stone and sand, and wear away the solid face of the rocky wall.

The sea is unresting in its efforts to smooth away all the inequalities of its shore, changing the sharp angle into a rounded curve, and carrying away wreck and *débris* from a jutting ledge, to spread them in some neighbouring hollow. This incessant re-modelling of the coast line shews itself under very different aspects in different localities, but on the whole, and as a general rule, its constant tendency is to level and equalize the whole coast line. If the level of the ocean were to rise a few hundred yards all over the world, the outline of the new coast line would be much more broken, standing out in swelling projections, and laid open by numberless arms of the sea penetrating far into the land. Such was the actual case in past prehistoric epochs, but the mud deposits of the rivers and the unbroken action of the sea have filled up the chasms and smoothed away the greater inequalities.

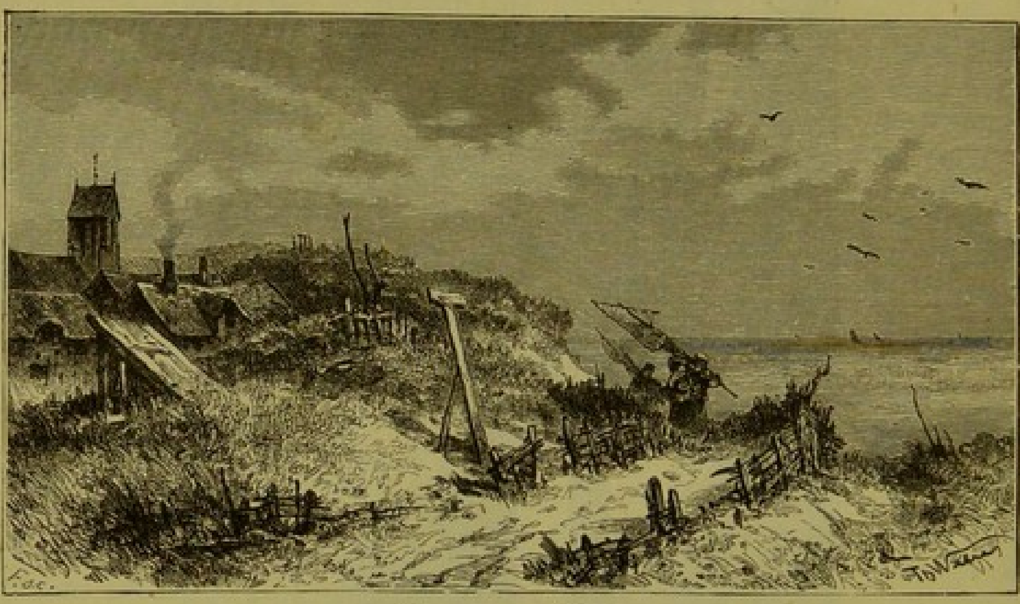
While we find that the low-lying shores are in many places exposed to the attacks of the sea, especially where a strong current flows toward them, we see also in other localities a natural rampart of sand raised to protect the land against its enemy. These ramparts or dykes are formed of sand cast up



FIORD IN NORWAY.

by the sea upon the shore, where it is dried by the sun, and blown inland by the wind. Along the French coast the dykes are formed of small light-coloured symmetrical grains of sand, alternating in some places with coarser fragments of rock, and in Bretagne with such an immense quantity of shells, that they are used as manure for the fields. The construction of dams resembling these dykes along the southern part of the French coast, and more especially between the mouths of the Gironde and the Adour, has created the curious ponds or coast lakes, which, following the shore line in a long chain, form one of the most remarkable characteristics of the *Grandes Landes*. These *étangs* are partly cut off from the sea by dykes of sand, and communicate with each other by means of narrow channels; very often, however, finding also an outlet seaward, as in the *étang* of Aureilhan. Standing on the brink of one of these miniature seas, and looking down into their salt or rather brackish waters, the traveller can study on a small scale every phase of the processes which were carried on at different times and on a large scale in the ocean—namely, the formation of muddy strata, more or less rich in lime and crustaceæ, layers of turf and meadow-ironstone, on the shallow marshy edges, with deposits of tufa, gravel, and even of gypsum and salt.

The northern coast of the North Sea is almost entirely encircled with dykes. Travelling northward along the shore from the mouth of the Maese, the sandy level is washed upon the left by the waves of the sea, while on the right hand, parallel to the shore, rises a hilly chain of drift-sand raised by the wind. Near Haarlem four similar lines of sandhills are found behind the first, and they are joined together by lines running at a right angle to the parallels. From the so-called "blue staircase" at Haarlem, these sandhills are seen extending to the north, west, and south of the town, while to the east the fertile plains of Holland, golden with cornfields, and covered with



SCENE ON THE DUNES.

dark-green oak forests, canals, villages, and flourishing towns, present a striking contrast to the waste and barren expanse of sea and sand. The white glare of the sand blinds the eyes in bright sunshine; the seaward slopes are bare of any vegetable life, and it is only on the land side that the greyish green of the sand willows, reeds, and grasses refreshes the sight. In the hollows between the sandhills, lie marshy pools of water, fringed with willows and water plants, and here and there a few stunted oak trees are found. The dykes are much larger and finer on the Danish coast, where they are often a mile long, and rise in two or three parallel chains. But the dykes have no element of rest or stability in their composition; it is their fate to wander unceasingly across their sandy bed. The great dykes on the west coast of North Jutland, upon whose ridges the sea gull makes a home, are pressing eastward, and sending out clouds of drift-sand with every wind. They have already partly choked up Lym-fiord, and buried the old Skager; now they are preparing to dry up the Skager-rack and Kattegat. This wandering of the sandhills is observed to the greatest advantage upon the little Frisian islands. The wind rushing down the openings of the valleys, which here and there intersect the chain of the dykes, whirls away the sand, and forms a new chain of hills, soon to be followed by another and another, as the sand wave presses farther inland. Nothing can resist this enemy; all life is crushed out beneath its tread, and man, however fondly he may cling to the spot which gave him birth, is forced to strike his tent, and beat a hasty retreat, to begin life again farther inland. Many a man who in his youth watched the sun set behind a certain dyke sees it in after years rise over that very hill, and then can watch the wandering mound drift finally to the east coast, and vanish in the sea. Planting the open shores with hedgegrowth is but of little avail against the invading foe; indeed, all the strength and skill of human force seems baffled by the silent, shifty attack of the wandering sand dyke.

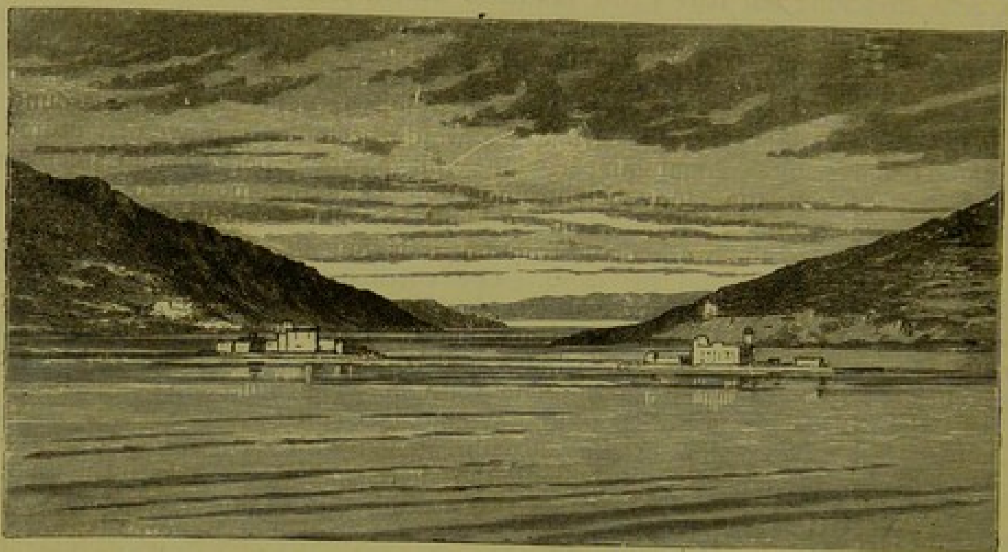
A district in process of entombment by the advancing sand presents a striking picture of utter desolation. Slowly, but surely, the resistless sand wave rolls on its silent path, burying beneath it the fresh green of the meadows, the carefully tilled cornfield, the many-coloured wild flowers found upon its track. Here and there some blossoming fruit tree, standing hopelessly above the rising sand floods, slowly shrivels and dies, losing its crown of buds, and stretching out bare dying branches with a piteous handful of yellow leaves. When the rising sand strikes against some cottage walls, it mounts slowly to the summit of the roof, and spreading all over the building, buries it completely, and thus creates a new sandhill, of which the centre is formed by the once cherished home, whose walls are gradually crushed together and beaten down by the weight of sand above and around them. Thus the dykes driven inland by the strong sea winds become the grave of cultured fields and human dwellings, often engulphing a whole village, where perhaps the steeple of the parish church rises from the sandy height, and stands like the monument above a grave over the village which once surrounded it. And if the rolling sandy masses of the dykes leave unfinished any of the work of destruction, it is quickly and thoroughly completed by the clouds of drift-sand and the wind. The small flour-like particles fall like finely powdered snow upon the plains and gardens, find their way through the smallest crevice of house or shed, and accomplish more in an hour than the slow sand waves in a month; for sometimes a sudden storm of these wind-tossed sand clouds has been known to change wide stretches of fertile plains into a desolate solitude. The old Roman road laid down beside the Bay of Biscay, from Bordeaux to Bayonne, has entirely disappeared beneath the sand, and several villages now existing are threatened with destruction from the same cause. The masses of sand extending along the shore spread out toward the land, creating a perfect desert, broken here and there by heathland and morasses, and constantly threatening to reach the interior of the country. Neither trees, nor high-roads, nor villages break the monotony of the sandy plain, crossed at times by one of the half-civilized inhabitants striding by upon high stilts. Here, too, buried villages have been known by the point of the church steeple rising above the sand in sorrowful token of past life and beauty.

We have said so much of the destructive ravages of the sandhills, that it is only just to record what influence they have had for good upon the culture of the land over which they pass. It happens sometimes that these wandering marauders are checked and entangled in some marshy swamp, where they sink in, and all within them that is still capable of analysis is extracted and absorbed by the vegetable acids, and rendered capable of fertilising the land. Sometimes the sand, falling in some large lake, transforms it first to a marsh, and then to meadow-land. The stranger looking round on the grassy fields of Holland, with their sleek well-fed cattle, their rich cornfields, smiling villages, and prosperous towns, each with its gay gardens and noble park, the forests of oak and beech trees, praises, it may be, the industry of the inhabitants, but fails to reflect that all this fruitful expanse of rich productive country was created out of boggy moor and quaking, treacherous morass by the very drift-sand which is usually the deadly enemy of all cultivation.

ISLANDS.

A single glance upon a map of the world is enough to shew how unequally islands are distributed over the various seas. The great oceans, such as the Atlantic and the Indian, are singularly bare of islands in their central expanse. Their islands are found gathered like a fringe before the coasts, grouped in front of the projecting curves of land, or lying like ruined fragments of former tracts of land, which formed the highroad between great continents. The Antilles, for instance, are like the pillars of a bridge which stretched from Florida to the coast of Cumana. The East Indian Island group is the wreck of a passage leading from Asia to Australia, and on an infinitely smaller scale the islands of the Ægean Sea formed the connecting link between Asia Minor and the peninsula of Greece. Different indeed is the aspect presented by the watery waste of the Pacific. With a few exceptions it may be said that its surface is merely sprinkled with a handful of island dust scattered over the centre of its area, and so presenting a decided contrast to the Indian and Atlantic Oceans. We may therefore divide the islands of the world into two great groups: 1. Coast islands; 2. Oceanic islands.

The islands near the coast, upon close examination, are generally found to be nothing but fragments broken off the mainland. We have already mentioned that the British Isles formed at no very distant period the north-



Bocche di Cattaro in South Dalmatia.

western promontory of the continent of Europe. This is shewn by the similarity of the flora and fauna of the south of England with those of the north of France, and by the same likeness existing between the animal and vegetable forms of Scandinavia and the north of Scotland. The ocean proper does not extend beyond the submarine plateau on which the British Isles rest. And in the same way it is proved that a great part of the East Indian Island group once formed part of the continent of Asia, although there was no actual union here with Australia; for between the islands of Bali and Lombak, Celebes and Borneo, there is a deep chasm in the bed of the sea, which probably indicates the boundary lines of the two continents. To the north of this line the forms of animal and vegetable life are Asiatic, and to the south Australian.

It is probable that far back in the secondary period a connection existed between the north of Asia and Australia, affording a passage for the primeval types of the marsupialia, but since that period it seems as if there had been no further union of the two countries, and the Australian lands have gone on developing the marsupial and other types in the different living and extinct races which we know at the present day. During a portion of the tertiary period Australia appears to have possessed its present area, together with the Papuan and Solomon Islands, and perhaps extended eastward to the Fiji Islands, and for a considerable distance to the south and west.

In this place therefore there has been a decided diminution in the mass of the land. The very appearance of the fan-shaped Celebes seems to indicate this by their peculiarity of outline. Little as we are inclined to lay stress upon purely chartographical resemblances, and much as we would warn the student against one-sided speculations based upon such likeness, we are yet disposed to admit the theory which sees in Celebes only a wasted and shrunken Borneo, that would have long since disappeared from the surface, had not its mountain range, like a skeleton, allowed us to draw the former outline of the mainland. In Gilolo the process seems still further developed. The history of the continent, as it appears recorded in the remains of animal and vegetable life, supports the theory that these islands are but the fragments of sunken masses of land. For instance, we have a right to expect that Celebes, which lies in the centre of the Indo-Australian island world, and is connected with it by many a coral reef and tributary islet, should bring before us a representation of the collective organic life of the south-east of Asia, in the remains of animal and vegetable life which should have reached it. So far from doing this, it stands independent and isolated, having little in common with Australia, and far less with Asia. And the Moluccas are found to have never been joined to Asia or to New Guinea, but to have formed an independent group, which arose at a very remote period, and may perhaps have occasionally been reached by wanderers from New Guinea. It is evident then that position alone furnishes no sure guide in determining whether or not an island formed part of the neighbouring mainland; in other words, the question cannot be solved by a mere consideration of the place as represented upon a geographical map. Botany, zoology, and geology must be called to the aid of the geographer. Even a submarine plateau formation, uniting the island to the continent below the surface of the water, is not of itself an infallible criterion of former union; for if it were so, Madagascar must once have formed part of Africa, and Ceylon must be a fragment of India; while we are sure, from the organic remains found within them, that these islands must always have been separated from the adjoining continents. And so with the beautiful islands of New Zealand, which have every indication of having been part of a lost continent now vanished beneath the surface of the sea, and never joined to the Australian mainland.

These coast or continental islands have been divided into three groups.

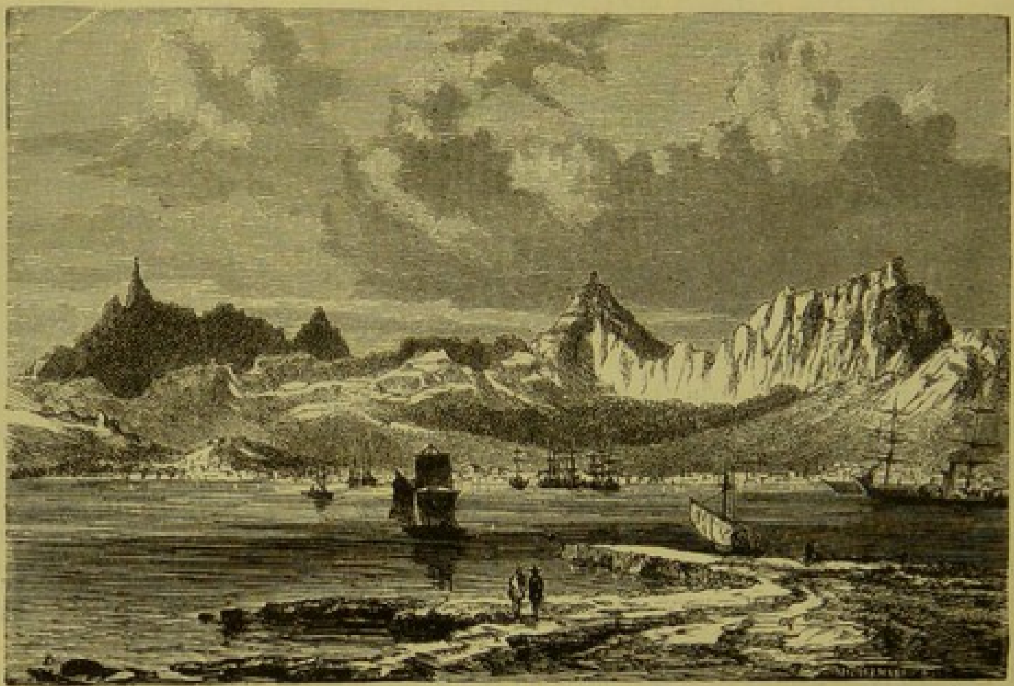
First, Islands recently separated from the mainland, and having the same forms of organic life as the adjoining continent; not distinguished by the exclusive possession of special organic forms in process of degeneration. Examples: the British Isles, Tasmania, and Japan.

Secondly, Islands separated from the mainland in prehistoric ages. Their animal and vegetable life already shews divergence from that of the mother-continent. If the separation took place at very remote geological periods, there may be even differences of type. Examples: Antilles, New Guinea.

Thirdly, Island groups, rich in native species, with an appearance of antiquity. Australia with reference to South Asia; Madagascar, Ceylon, and perhaps New Zealand.

Oceanic islands have no direct relationship to the continents. They appear generally in groups or archipelagos, and are seldom isolated. Sometimes they appear in long curved lines, the arch of the curve being generally turned towards the ocean. These islands are divided into three groups. First, young, low islands built of coral, poor in all forms of organic life, especially in reptiles and mammalia; distinguished by no exclusive possession of specia animals or plants. Examples: the Atolls of the Pacific Ocean, which are best represented by the Kerguelen Islands. Second, recently formed islands created by volcanic action; richer in forms of life than the low Atolls, bu without special forms. Examples: northern group of the Marianas, St. Paul and New Amsterdam. Third, old island-volcanoes, richer than the preceding with their own types of plants and animals, asylums of refuge of extinc continental species. Examples: Madeira, Ascension, St. Helena, Bourbon Mauritius, the Galapagos, etc. The second and third groups are called *high* oceanic islands, the first comprises the *low* island groups.

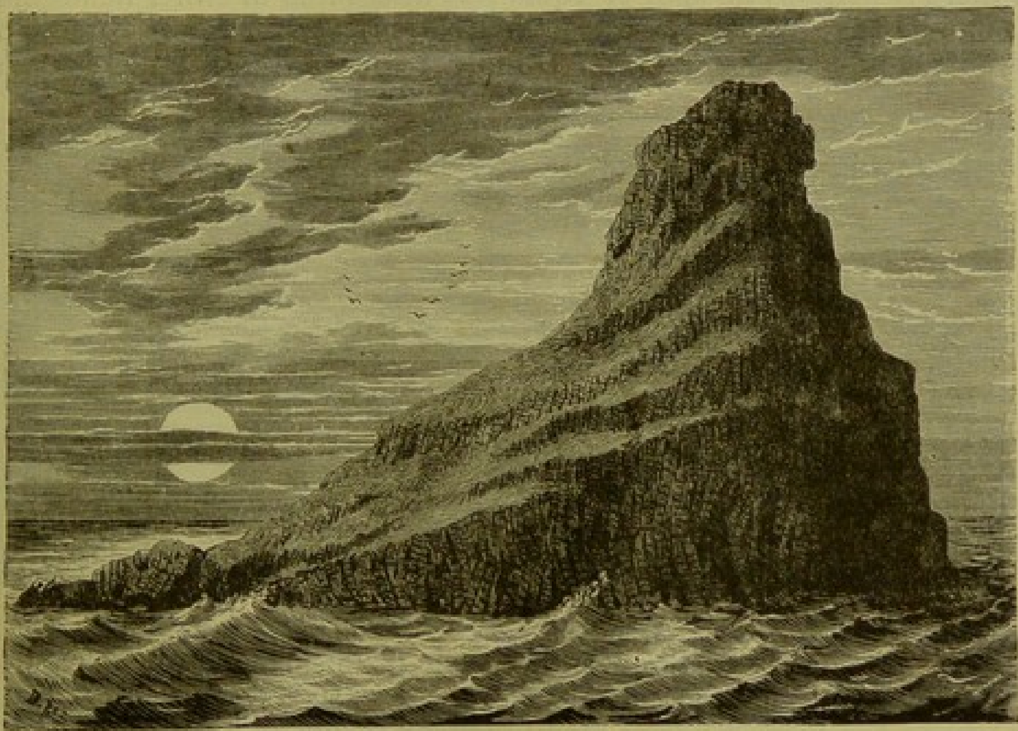
The high oceanic islands are almost exclusively of volcanic origin. They rise sheer out of the sea's depths, are never of any great extent, and no unfrequently contain within them a central lake. which is connected by severa



Port Louis, Mauritius.

channels with the ocean. An example of this kind of formation is presented by the Island of St. Paul, in the Pacific. This rock, which can with difficulty be approached by the sailor, rises almost vertically from the waves—a mighty crater, the eastern side being broken, and admitting the entrance of the boiling surf within its rampart of rock. Grim and bare it rises before the eyes of the traveller; no tree or shrub breaks the monotony of the rock, and nothing is heard above the noise of the waves, but the plaintive cry of the seal, or the bellow of the sea lion rising out of the foaming waves upon the shore. Clouds of smoke and steam are seen issuing from the mouth of the crater, and hot springs bubble at the base and along the ridge, which, broken and crumbling away by the violence of the waves, affords a difficult passage to the interior. This entrance did not exist in 1696, when Vlaming discovered the island, and probably was first seen in 1793. The vegetation is very poor and scanty, consisting only of coarse grasses and moss, and the culture of imported varieties of fruit trees has not been successful. Mounds of ashes lie in desolate heaps along the south-western shore, giving warning of the subterranean forces below. The fauna of the island is as poor as the vegetation; very few quadrupeds are found upon it, and even these, such as goats, pigs, etc., have been imported from other countries, and do not thrive in their new home.

Sometimes the raised circular rampart seen round most volcanic islands is broken up in several places, as in the island of Santorin, in the Ægean Sea. Santorin is not exactly to be classed as an oceanic island, but it is one of the best examples of the formation we are now considering. It was once undoubtedly the rampart of a vast crater which was broken in many places, either by earthquakes or by the action of the waves. These breakages took place in some prehistoric age. We have at least no reason to believe that Pliny had Theresia or Apponni in his mind when he wrote that in the fourth year of the 135th Olympiad a new island had arisen near Santorin; but there is no doubt as to the formation of three rocky islands inside the old crater.



Basaltic Island Cast up by Submarine Volcano.

Plutarch writes that Paläo-Kaimeni arose first, 570 years after the building of Rome. Seventeen centuries and a half later, Mitro-Kaimeni arose, and there occurred a succession of submarine eruptions to the year 1650, without, however, any new island being formed. On the 18th and the 22nd of May, 1707, slight shocks of earthquake were observed in Santorin, and on the following morning a dark mass was seen between Paläo and Mitro-Kaimeni, which was at first taken for the wreck of a stranded ship. Some sailors who repaired to the place brought back the astounding news that a rock had risen above the surface of the waves at a place where the sea was more than 525 feet deep. The island rose visibly higher, and oysters were found clinging to the rock. On the 13th of June it stood about twenty-five feet above the level of the sea, and covered an area of more than 3,150 feet. Two days later the water round the island was much hotter than its ordinary temperature, and on the next day a row of black rocks rose above the surface, increasing in height on the 17th and 18th, while the submarine thunder rolled below. The following day

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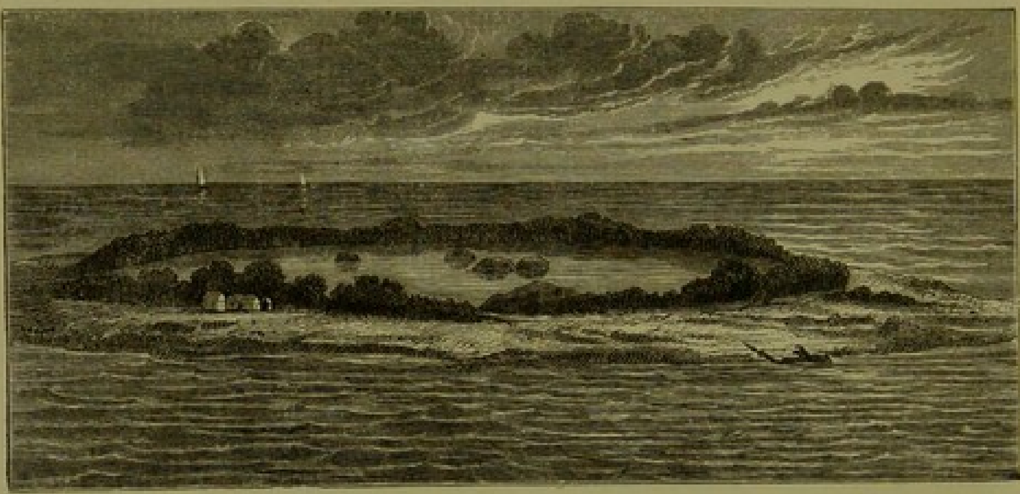
the chain of rocks formed an unbroken line, and a crater threw out ashes and red-hot stones. The island increased in circumference, and at last reached the size of nearly five miles.

Except for one eruption in the year 1768, the island-forming forces near the island of Santorin remained in abeyance for nearly a century; but at last, in 1866, there was a fresh uprising of rocks, accompanied by phenomena which we must examine more closely in another chapter.

If we recognise in Santorin an island where the volcanic forces seem yet unspent, we find in Fernando Noronha an example of an extinct volcanic formation. Exposed to the wide rollers of the Atlantic, this bare and arid island, with its spear-like points of rock, its conical peaks, and overhanging crags, presents a wild and desolate appearance. Kerguelen, with its torn and jagged cliffs, is another specimen of a worn-out volcano. The poverty of its organic life is very remarkable, and was noticed by Captain Cook, who says that there is perhaps no spot of equal size discovered in either hemisphere, in the same latitude, which presents such a barren field for the researches of the naturalist as this desolate place. He might fairly have extended his remarks



Atoll, or Coral Island.

to 10° lat. below and 20° above in the same peninsula, and thus have defined the limits within which this poverty of animal and vegetable life exists : even Spitzbergen has three times as many growing plants as Kerguelen.

From this fact we might conclude that the island never formed part of the continent. So much is certain, but from other reasons. The poorness of the vegetation depends very much upon climatic influences, and a great number of petrified trees shew that many parts of Kerguelen were once covered with forest growth.

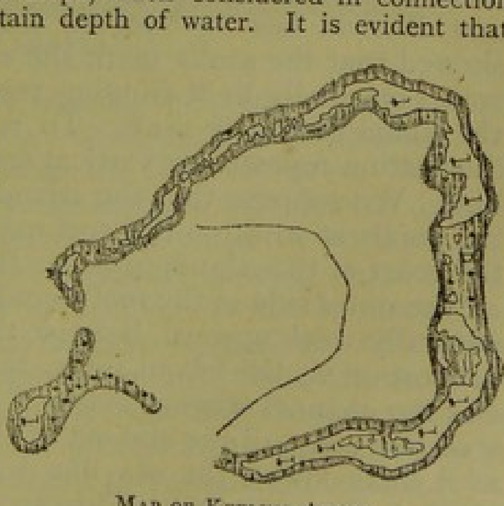
The low oceanic islands generally owe their existence to the industry or the lime deposits of the coralliferi, and are known by the name of coral islands or reefs. Of great interest to the geographer and the naturalist, they are the terror of the seaman overtaken by a storm in their dangerous vicinity. Happily these busy toilers of the sea, the corals, are restricted to a zone on each side of the equator where the water has at least a temperature of 19° C. As a rule this zone is found between the twenty-eighth degrees of north and south latitude; but where, as on the west coast of South America, the temperature is lowered by cold ocean currents, the corals retreat nearer to the equator. The lower strata of water does not seem so favourable to their development, and they are seldom found more than twenty-five to thirty fathoms below the surface; although on the so-called Purtales plateau, on the American coast, a reef with living corals has been found at a depth of about three hundred fathoms.

The material of the coral reefs consists, in by far the greater number of its masses, of the detritus of corals, echinodermata, many kinds of shells, reticularia, and other living creatures, which deposit, not only the salts of lime extracted from the ocean, but their own dead bodies, to form the hard substance of the rock. There are many different kinds of coral reef, some of which are entirely made up of small rounded grains, and some partially crystalline. Indeed, every variety of formation, from the loose conglomerate or coarse tufa-like rock, where the traces of organic remains are yet clearly visible, to the perfectly compact limestone, with no trace whatever of its living origin, except, perhaps, on the outer margin of the reef, and in no way to be distinguished from hard alpine, or even from palæontological limestone. This compact, hard limestone may be considered to be the prevailing form of the coral reef. The island of Metia, which consists of a reef 265 feet high above the level of the sea, contains a number of caves filled with beautiful stalactite and stalagmite formations: the clefts and fissures of the rock, and the caverns formed by the detritus of shells, being generally coated with crystallised lime spar.

The nullipora play a prominent part in the formation of coral reefs. They are found among the breakers encrusting the smaller coral fragments and shells with their secretions of lime, and forming them into a solid piece of masonry capable of resisting the wildest attack of the waves. In other places they are found to create independent strata of compact limestone.

These coral reefs are divided into three classes: coral banks or fringed reefs, but slightly raised above the surface of the sea, and directly joined to the neighbouring coast; barrier reefs, which follow the direction of the coast, but are separated from it by a channel of water; and atolls, or circular rings of reef enclosing a lagoon of water, which is sometimes connected by an opening with the sea.

Darwin has written at length upon the origin and development of coral reefs. With reference to the fringed reefs, he states that their formation and dimensions depend entirely upon the greater or lesser incline of the submarine slope, when considered in connection with the fact that corals are not found below a certain depth of water. It is evident that where the sea is very shallow—for instance, in the Persian Gulf and in certain parts of the East Indian archipelago—the reefs will lose their character of coast or fringing reefs, and appear as scattered, isolated rocks, sometimes of very considerable extent. Since the conditions on the inner side of these reefs are in many respects unfavourable to their development, the growth of coral is more rapid on the outer side, which accounts for the fact that most reefs of this nature are higher and more perfect along their outer edge than in the centre parts. The lower strata of islands are protected and sheltered by the coral reefs from the action of the waves, the strata above their influence being worn down to the very edge of the water. This is strikingly the case with the islands of the Red Sea, which formerly lay parallel to the land, with a channel of deep water between them and the coast. The reefs which now cover their base have the same relation to the land as fringing reefs, although they do not belong to that class.

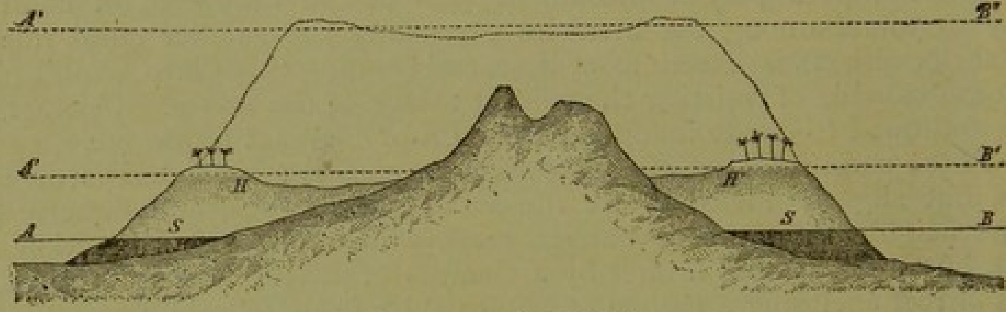


Map of Keeling Atoll.

Type and representative of the barrier reef is the great Barrier Reef in front of the north-eastern shore of Australia. This reef extends, with few interruptions, for 1,250 statute miles in length, and its distance from the shore varies between twenty and thirty miles, in some places even fifty to ninety. The largest arm of the sea enclosed by this reef is ten to twenty-five fathoms deep, and has a sandy bottom; the depth increases toward the south, where it is farthest from the shore. As usual, the outer margin is higher than any other part, and the sea outside it is of great depth. Several navigable channels afford a passage through the reef.

The atoll is found to excite more interest than any other kind of coral formation. "Who," exclaims Darwin, "would not be struck with wonder and admiration on catching sight, for the first time, of this vast ring of coral rock, often many miles in diameter?" Sometimes a low green island is seen beyond it, with a shore of dazzling whiteness; outside it is the foaming surf of the ocean, and within it a broad expanse of tranquil water of pale-green colour and exquisite purity. Keeling atoll, in the Indian Ocean, is a fair type of the class of coral reef. Here the ring encloses the lagoons on all sides with the exception of the north, where there are two openings, one of which is navigable. The breadth of the reef varies from 250 to 500 yards. Its surface, over which the waves of the sea break in high water, is horizontal. It is studded with several small islands, composed of masses of rock broken off and flung together by violent storms, and first to be found 200 and 250 yards from the exterior rim of the reef, and the central lagoon is shallow, and in the southern portions nearly filled up by mud banks and coral formations.

If we make inquiries into the origin of coral reefs, we are met first by the old and wholly untenable supposition that the atolls rest upon submarine craters. No complete theory was brought forward as to the origin of barrier reefs until Darwin published his work upon the subject, but it was generally



GROWTH OF A CORAL REEF.

assumed that the great Australian reef rested upon a precipice running parallel with the shore. It was evident that the fringing or coast reefs grew most rapidly along gently sloping depths where the water is generally turbid; and Darwin has now solved the problem of the two former classes. He shewed that the atolls mark the situation of sunken islands, round which the corals originally built fringing reefs, which became barrier reefs and atolls as the island gradually sank. To represent the process, let the accompanying illustration represent a vertical section of an island, and A B stand for the sea line. We suppose that the island is slowly sinking beneath this line A B, and the corals at work on the reef marked by the letters S S, and running round the coast of the island, continue their work in an upward direction, and chiefly on the outer side of the reef round which the breakers are raging. They would naturally work upward, because they only thrive in a certain depth. Now in proportion as the island sinks, the water advances farther toward the land, and the channel flowing between the island and the reef becomes wider. At a certain stage of the sinking of the island, which, of course, becomes smaller as it sinks lower, the sea line will have risen to the height of A B, and the corals built up to H H. This section drawing represents one enclosing reef, and is, in fact, a section taken from east to west through the highest point of the island Bola-Bola. Should the island sink deeper still, and the sea line reach the line A″ B″, the island will lie buried beneath the waves, and the corals will have formed an atoll round it. No further sinking can then produce any change of type, except a diminution of size, as the reef does not rise exactly vertical from the waves. It is obvious that when the sinking is greater than the upward rise of the coral building, the corals die out and the reef is "drowned," leaving an atoll-shaped bank of dead stone; and the continued sinking, together with the heaping up of *débris*, will efface the atoll-shaped formation, and leave nothing but a bank with an almost horizontal surface. The extension of atolls and barrier reefs, in accordance with the theory just stated, shews us also the extent of the basin of depression. We learn at once from these indications, that the central and western parts of the Pacific, and the bottom of the Indian Ocean between Madagascar and Ceylon, are slowly sinking. And more than this; we are led to expect that the rings and corals, like the rough draft of a map, shew us still the general direction of the islands round which they have formed themselves. It is exceedingly probable that this is the case with the atolls of the South Pacific, as far as concerns their

BOLA-BOLA (Society Islands).

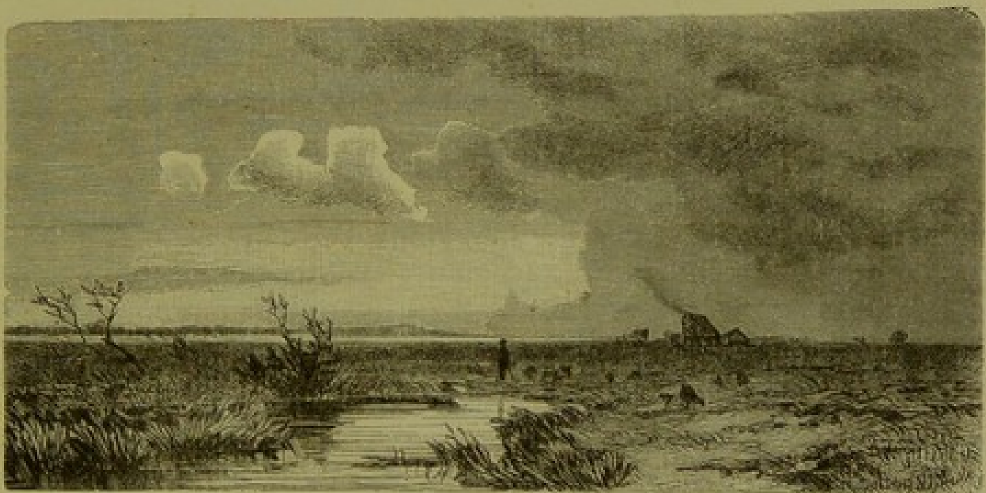
direction; for nearly all the mountainous islands and coasts in the South Pacific have the same direction; namely, north-eastern Australia, New Caledonia, the northern half of New Zealand, the New Hebrides, the archipelago of the Solomon, Navigators, Society, Marquesas, and Austral Islands. In the North Pacific Ocean, the Carolina atolls nearly touch the north-western chain of the Marshall atolls, just as the row of islands running from east to west, from Ceram to New Britain, touch New Ireland. In the Indian Ocean, the Laccadive and Maldive islands extend almost parallel to the western mountains of India. There is moreover a great similarity between atolls and ordinary islands in their shape, and in the way in which they are grouped together. Thus the outlines of all the large groups of atolls, as well as the outline of each separate atoll, are lengthened out in the same direction.

While the atolls thus bring before our eyes the sunken or sinking regions of the earth's surface, the fringing reefs shew us that the land to which they are attached has not sunk. But whether or not the land rises is the question, which can only be answered by an investigation of the local circumstances. As a matter of fact it is found that in many cases one of the clearest signs of rising is the presence of these reef-girt shores, and also that there are no active volcanoes to be found in the regions of depression, while they are frequently met with where the land is rising. If the two great types of formation, barrier reef and atoll on the one hand, and fringing reef on the other, were traced upon a map, they would present a grand and harmonious picture of the movements to which the earth's crust has been subjected within a recent period. We should then see mighty tracts uplifted, and from time to time volcanic masses breaking out upon their surface. We should see other large tracts in process of depression, and without any sign of volcanic action, and we may be convinced that the movement must have been sufficiently slow to allow the corals to grow up to the surface, and sufficiently widespread to have buried each separate mountain, above which the atoll rises like a monument to mark its place of sepulture below the waves of the ocean. Now-a-days, and happily for our seamen, we find the reef building-corals have disappeared from the seas of the European continent; but our geologists tell us that there was a time when Europe also was the home of these creatures, who throve so well that they built reefs of immense extent. The steep masses of the dolomite limestone and coral formation belong to an earlier phase of the earth's development, and vast masses of reef rocks have been found in a wide belt along the northern margin of the central chain of the Austrian Alps. In the trias period, it is believed that this part of the Alps was encircled by coral reefs. At that time slow depressions must have taken place in Europe, analogous to those which we now observe in the South Pacific. At the same time the coral builders pressed forward, and in the Jura period reached the seas of central and north-western Europe. Not until the so-called chalk period was there a climatic change, which proved destructive to the development of corals in Europe, and relegated them to those waters in which they are found at the present day.

Plains, Heaths, Tundras, Steppes.

Upon the solid surface of the earth which rises above the level of the sea, mountain and plain succeed each other in manifold variety. But the plain or lowland occupies by far the greater part of the land, and extends in an almost unbroken level from Behring's Straits to the German Ocean, and from the ice-clad shore of Cape Taimyr to the northern slopes of the Paropanisus. Two-thirds of the American continent are plains, known under different names according to their locality; the lowlands of both halves of this quarter of the globe appearing as a vast whole, although divided locally into several beds or basins. Owing to the unsymmetrical position of America with regard to the equator, the character of the lowlands in North America is very different from those of South America. The desolate plain of Hudson's Bay, in the north of North America, has all the terror and gloom of a second Siberia. Toward the south, this district is separated from the lowlands of the Mississippi by the low rise of the Black Hills. The Mississippi plain is of great extent, and forms the wide-spreading cradle for the development of future civilization. It rises gradually towards the west, where it meets the boundless stretch of prairie land, whose conversion into cultivated field and meadow is only a question of time.

If we turn to South America, we find lying almost directly below the equator the vast impenetrable forest plains of the Amazon, where a pebble is as rare as a diamond. To the north of the *Selvas* lie the *Llanos* of the Orinoco, which appear now as a desolate sandy waste, now as a rich grassy sea, according to the season of the year. No crag, no hill, rises island-like above the waves of this immeasurable sea. Here and there irregular undulations, some hundreds of square miles in extent, are seen raised above the surrounding plain. The natives call these higher levels "banks," as if the secret of their origin had been unconsciously preserved in the common speech of the country, to bear witness of the long-distant day when these plains were shallows rising from the ocean bed of the plain. To the south of the Selvas of the Amazon lie the Pampas or grass plains of La Plata, stretching far away to the Atlantic coast, and the desolate Patagonian plain, which reaches the southern point of South America. The boundaries of these great southern plains are so far distant, that the northern limit is marked by fringing lines of palm trees, and the southern lies sheathed in unyielding ice. While we find the lowlands of America stretching eastward toward the Atlantic, the plains of the old world are found lying before the northern mountain ranges. Where these plains are not covered with forest trees, but appear as steppes or



VIEW ON LUNEBERG HEATH

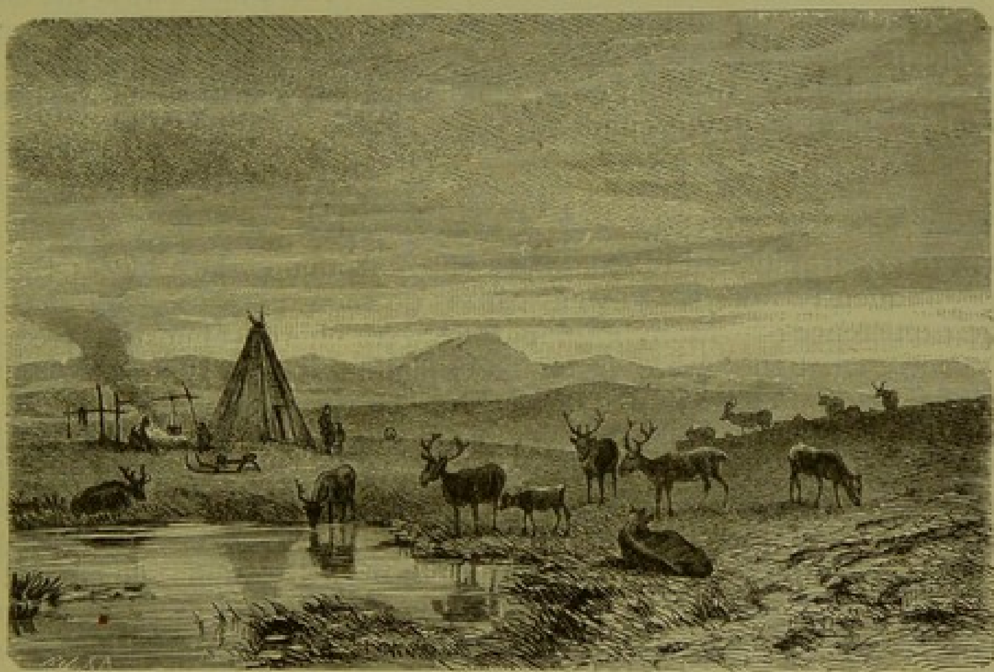
heath land, with patches of coarse grass or dwarf shrubs, the traveller is irresistibly reminded of the ocean plains, and compares the voiceless spaces round him, reddened with the setting sun, or arched over by the starry host of heaven, to the silent, shadow-filled ocean, unstirred by any break of coming storm. And fancy is here the handmaid of geographical truth; for where the tired steps of the wanderer plod heavily through the sand of the Mark, or range over the salt desert of the Steppes, the waves of great seas once flowed unchecked, and have left the traces of their presence in many a sedimentary deposit.

The plains are frequently intersected by ridges or swelling curves of land, especially where they indicate by plateaus of moderate height the transition to highland plains; and their surface is also broken by numerous lakes of various sizes; and in other respects the appearance of the European plains differs very greatly one from another. The Landes by the Gulf of Gascony resemble a great desert of sand, while the plains of the Sologne are broken by patches of heath land, and those of the Campine between Belgium and Holland are filled with sand and moorland. Passing through the moors of Friesland to Hanover, we find between the Aller and the Elbe a gradually sloping table-land rising toward the south and descending toward the north. This sandy plain is known as the Luneberg Heath; and several small villages, surrounded by plantations of stunted oak and beech trees, are found upon its surface. The sandy plain extends beyond the Elbe as far as Brandenburg, which is called the "pounce box" of Germany, but its monotony is greatly relieved by numberless small lakes and rivers and the presence of fragrant woods.

The German plains are eminently calculated to shew the changes which have taken place during the most recent phase of our earth's development. In the diluvial period they formed, as we know, the bed of a great sea; icebergs came floating by upon their waters, and lay stranded upon their shores, strewing them with fragments of rock from the distant shores of Scandinavia. Then, as the sea sank, and left behind it the muddy, sandy soil steeped in salt, the plain assumed the character of the steppes. It underwent the same process which we see now taking place in the once watery plains of Asia, especially in the neighbourhood of the Aral and the Caspian Sea. Numberless fragments have been found in the old alluvial bed near Westeregeln, which are proved to be the remains of animals belonging to steppes, earth crickets, hares, and wild horses. After awhile the form of the steppes disappeared, and was succeeded by that of the forests; not by a sudden transition, but gradually, as the wood advanced, the animal life of the plain retreated eastward, where a more favourable *terrain* awaited it. In the course of centuries the forests disappeared under the joint attacks of time and cultivation, and the present condition of things came into existence.

The Hungarian plain is broken by tracts of fertile ploughed land, heaths and meadows, and wide swamps, all framed in a stretch of desolate sand often lashed into cloudy whirlwinds by the wind. Very similar in appearance is the upper part of the Sarmatian plain. In the middle course of the Petchora in Archangel the traveller meets with rich meadows and vast primeval forests of pine, fir, and beech, which lend to the scene a strange, sombre beauty. Northward, as he draws nearer to the arctic regions, the landscape is more monotonous; the willow scrub retreats, and makes way for the inhospitable *tundra*, the most forbidding district of Europe, with its miles of swamp and patches of reindeer moss stretching out to the distant frozen sea. Its soil has been frozen earth for thousands of years. Death-like monotony is the impression made by the whole extent of the tundra lying outspread in wide, dreary, level reaches. No change, no play of light and shade, no night all the summer through. Light, wind, and sound die out, lost and spent over its limitless surface, in strange tremulous shiverings: all is dumb and lifeless. One endless summer day lights up the northern tundra; the sun is grey and veiled, and shines like moonlight, so that it can be gazed at without pain. The very light is dulled and enervating, and the human life dies down under its influence to the low, blunted level of the Samoiedes. Crushed down by the monotony of its surroundings, all thought is turned inward upon itself, unchallenged by the thousand voices and sights which called it to healthy outward life in the solitudes of the high woods. Tundras are divided into high and low, according to their level above the water plain of the locality. Most of the widest stretches of the plain are but little raised above the level of the sea, and present an aspect of the most unspeakable desolation; while the low tundras are sometimes relieved by a patch of green or a pool of water, in consequence of the temperature being higher nearer the ground. The moss fields or moors are the wildest part of the low tundra; consisting of water masses, they cannot reach into the heart of the colder regions, as the frozen ground prevents their further development. Of course the wet, quaking soil of the swamps is unable to reach the frozen land of the ice plain, for in the latter region the ground is as hard as iron. These wet swamps are found on the lower course of the river Obi, in Siberia, and run southward, gradually changing into wide green levels, and then into high, gloomy pine woods.

Turning our back upon the frozen north, crossing the ridge of thickly wooded land which stretches from the Ural Mountains to the Baltic Sea, and the fertile region of the central Sarmatian plain, once overgrown with forest trees, we reach first the grassy plains of the south Russian plateau, the pasture grounds of many wandering herds, and farther on the sandy steppes, with their tracts of heath and salt plains; the outrunners of the greatest desert steppes in the world, reaching from the mouth of the Danube to the river Amour, and forming a barrier between the civilizations of Europe and China, between the wild north Asiatic hordes and the cultured Hindoos. Steppes are of three kinds: salt, sand, and grass steppes. Neither of the two former classes is fitted for the permanent home of man or animal; the salt steppe because it contains no good drinking water, and the sand steppe because the water is only to be found deep below the surface. But the grassy plains are the home of many a wandering tribe; but even these steppes are varied in their capacity



SCENE IN THE TUNDRAS.

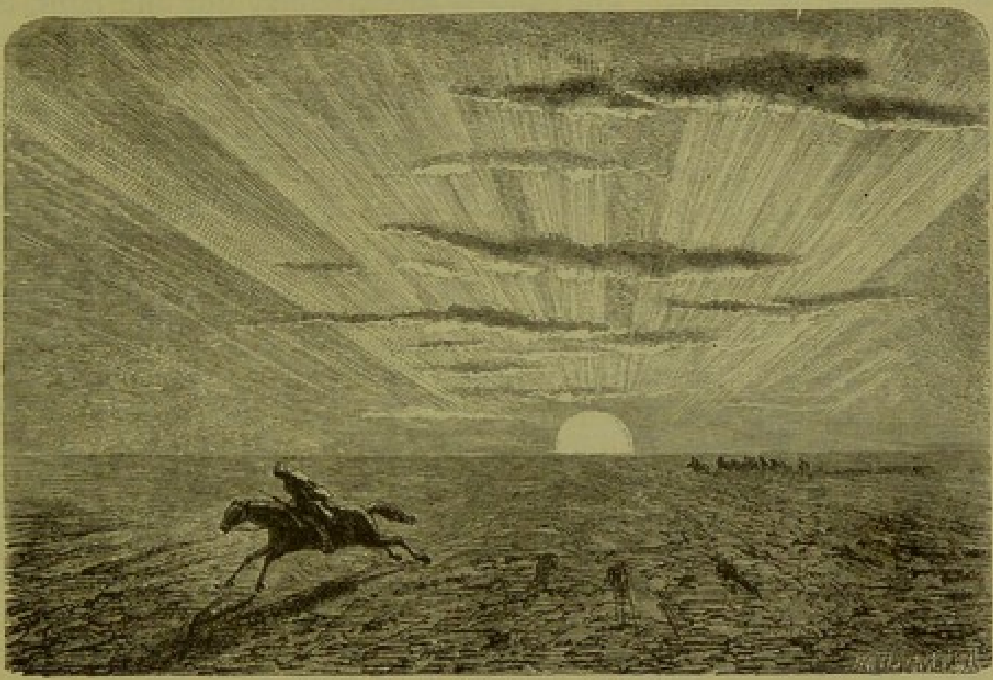
for providing food for the cattle which exist upon them. The plains inhabited by Kirghis and Kalmuck tribes are covered with tall dense grasses, through which it is difficult for any vehicle to force a passage, while the growth upon the South Russian plains is poor and scanty. No green turf of any extent is found between the shores of the Dnieper and the "gardens" of Simferopol. The grass is patchy, and altogether does not cover more than a third of the surface; the rest is overgrown (in the spring only) with tender herbs, which are soon scorched up, and leave a dead, burnt soil behind them. In the intervals of barrenness found between the grassy patches of the South Russian plains, nothing is seen but a short-lived growth of bush, which appears in the spring, and soon shrivels into dust, leaving the soil bare for nine months of the year; and even the plants which form the turf or grass patches only last for about three months, from the middle of April to the middle of July, the land being only good for pasturage in the other months, and not then when the snow falls on the ungrateful soil. The close connection between the rainfall and the scanty vegetation of the South Russian plains is shewn by the dryness of the superficial strata of the earth during the summer months. The ground opens in wide clefts, and all vegetation dies down.

Still more desolate are the plains of the Caspian. The image of the barren desert is presented by the country round the lower course of the Volga: large sandy basins parted from all cultivated nature by the wide barrier of the river, and framed with tall melancholy reeds, through which the wind sighs and rushes. The dreary monotony of the scene is beyond description. Nothing meets the eye but wide treeless plains, meeting the grey sky line on every side of the horizon. Not a curve or swelling of the dull level; at the best a group of stunted trees stripped of every leaf by the shrieking wind of the desert, and a wretched village here and there. Quickly the traveller drives across the boundless plains, meeting with no change of scenery, except the sudden gap of a chasm torn open by the tempestuous rain, or the stagnant waters of some gloomy swamp. Here and there may be seen some desolate hut, but after a short breathing time the journey is resumed across the endless waste. Sometimes the distant figures of wandering Kalmucks are seen afar off, as the mounds erected to mark the grave of some fallen warrior. For hundreds of miles the only sign of human life is the wheel-track of the carriage traced on the hard clayey ground.

DESERTS.

Before geography had taken its present rank among the sciences, the question was frequently raised, "to what causes do the great deserts of the globe owe their existence?" Many explanations were offered, almost before people knew exactly what they were trying to explain. It was suggested that the desert of Sahara was created by a reckless cutting down of large tracts of forest trees, or that the sea had washed away the fertile loamy soil, and left a substratum incapable of producing vegetable life. Alexander von Humboldt wrote more thoughtfully and truly of the influence of mere geographical position upon the formation of these vast plains. He pointed out that the African desert was exposed to the action of hot dry winds which had just crossed the sun-scorched continent, and that together with these burning winds were the absence of rivers and the moisture-giving growth of wood, or the stream-washed precipices of mountain ranges. Even the combined effects of these causes would not, he thought, account for the immense stretch of sand, and he inclined to the supposition that the sea had once passed over the plain, and robbed it of all its vegetation. Other scientists considered that the trade-winds alone were sufficient to explain the barrenness of the Asian-African desert, and that the arctic current of wind coming from the polar region to the northern part of Asia towards the south-west exerted a drying influence as far as the Atlantic shores of the Sahara. But this supposed current has no existence in fact. There is a complication of atmospheric currents in western Asia, and it has been proved that the south-west wind prevails across the Ural as far as the interior of northern Siberia. Any stream of atmospheric air from the Asiatic steppes over the Sahara during the summer months is utterly impossible; on the contrary, the wind blows over it from the Mediterranean Sea. In the winter a dry Asiatic wind crosses the Sahara, but the east and north-east winds are by no means prevalent there.

The Sahara is widely different in its characteristics from the Asiatic desert plateau; if the Atlantic Sahara languishes in the very sight of the ocean, while the trade-winds are blowing seaward, the desert of Gobi, by its low atmospheric pressure, attracts the vapour-laden strata of the Pacific. But not a drop of the life-giving element can reach the arid highland plains; for as the air rises higher and grows cooler it empties all its watery treasure on the plains of China. And thus we find the northern slopes which skirt the Mongolian plain are slightly wooded, because the moisture of the rising masses of vapour is condensed there, and returns back to the ocean as river or streamlet, while the southern slopes of the same mountain range are bare and treeless. In the south-eastern part of the desert of Gobi the thermometer stood in July at 129° Fahr. in the shade, and in the night frequently sank not below 77° Fahr. Not a breath of air cooled the atmosphere, for every breeze only stirred the lower hot strata of the air, and increased the heat. Not a cloud was visible upon the sky. The dryness of the air was terrible, and no dew fell on the ground; the rain clouds dissolved in the air. This interesting phenomenon was seen most clearly in South Alaschan, near the Ghau-su



SCENE IN THE DESERT OF MONGOLIA.

mountains. The rain falling from the heavy cloud over the desert could not reach the ground, but was converted into vapour in the burning strata of the air below it. This only took place when the rain clouds were small.

Contrary to the enclosed desert of Gobi, the Sahara lies open on all sides, and its atmospheric currents have not become dry by leaving their moisture on any mountain-side, but are dried up at their source. The trade-wind therefore has a hand in the desert formation, even if it does not blow in a curved line from the arctic circle in north Asia to the boundaries of Senegambia; but its influence must not be over-rated.

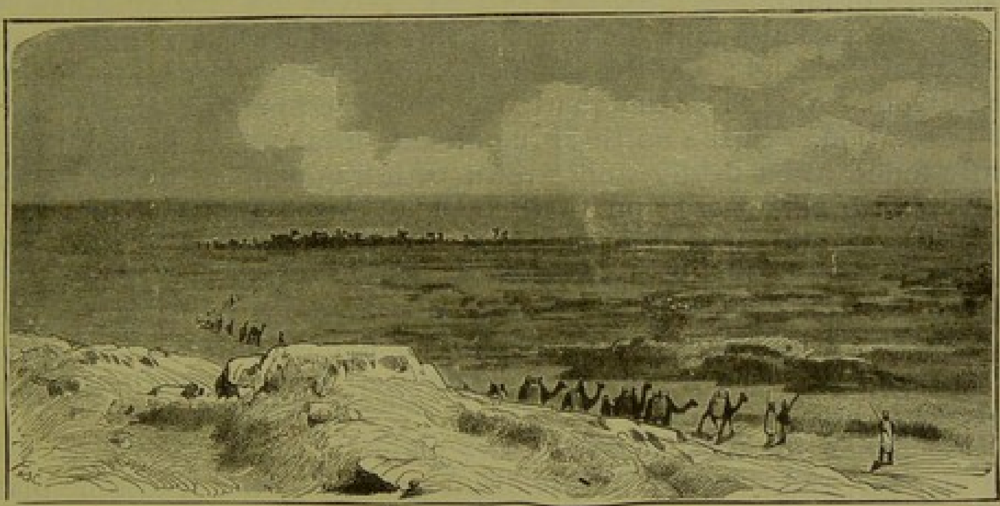
The plain of Sahara is the great typical desert. Its name comes from the Arabic "cahhra," which means *the plain*. Not that the great desert is by any means an unbroken plain, or destitute of great variety in its physical characteristics. The true sandy desert occupies but a relatively small portion of the space marked upon our maps as the desert of Sahara; and even upon the surface of this "true" desert the distribution of sand is very unequal. The stratum of the sand on the road from Mourzook to Wau is so thin that the underlying limestone is visible through it, while in the Libyan desert the dykes and mounds of fine yellow quartzs and rise 110 yards high and thirty miles long, succeeding each other as far as the eye can reach, like the waves of the sea. The sandy region attains its greatest extent in the Libyan desert, and masses of sand still drift in from the Mediterranean, to settle down upon a bed which in a geologically recent period was buried beneath the waves of the sea. These sand floods extend westward to Tripoli. Near that town the sandy stretches are varied by plantations of palm trees and fields of corn; true deserts of yellow sand, passing like a yellow ribbon from west to east, between fields of wheat and barley.

The western Mongolian desert, between 92° and 96° west long., contains plains of sand perfectly corresponding with those of the Sahara and the Arabian desert. Mounds of loose sand are blown together and scattered again by the wind: a mere breeze is enough to wipe out all trace of a long caravan crossing the waste. The sand is so extremely fine and light, that in sudden storms of wind trenches of thirty or forty feet deep are hollowed out, and swelling waves are raised like those of the Libyan desert, making the journey tedious and difficult to the camels as they cross the shifting plain.

It is true that large stretches of the plain of Sahara are covered by waves of sand, which were once sandy bars and dykes of the sea; but the whole desert is by no means the product of the ocean alone. Very much of the sand is of local origin, formed from the soil of the desert plain by the sudden changes of temperature and the action of the wind. There are many such centres of sand radiation, and the mechanically powdered fragments of rock are found in every phase of transition from crumbled stone to fine drift-sand. The ground above Kartoum, to the west of the Nile, consists partly of rose-coloured porphyry granite, and the whole surface of the rifted slope of rock is bestrewn with fragments of different sizes. At the foot of the north-west slope of the Arasch-Kael the plain is entirely covered with coarse sand made of broken porphyry, on which a scanty vegetation manages to exist. Fragments of rock are seen lying about at a mile and a half's distance. On the east and south slope of the same mountains the ground is also covered with the decomposed porphyry granite. On the road between the high plains of Asgar and the valley Edjendjer, a halting place for caravans, where some little vegetable life appears, the plain gradually rises for several days' journey toward the barren naked desert plains of the south-east. The ground is composed for the most part of coarse gravel mixed with finely powdered granite, and here and there with a dark-blue porphyry-like stone and large white crystals of feldspar. Farther on to the south-west are numerous sand-hills. The granite lying only a few feet below the surface relieves the monotony of the sandy plain by its beautiful blue colour. Sandhills and granite ridges succeed each other. Still farther on, in the desolate region of Ikademmelrangh, the granite formation is in process of complete disintegration, and has reached the appearance of sandy *débris* broken by isolated cylindrical fragments. These points, seen from the highest levels of the desert, look like so many islands on a sea of sand.

It would be easy to multiply these instances which shew in how many places the sand of the desert is of purely local origin, made from the underlying sandstone, quartz, salt, and gypsum. The coherent sandstone in the north-western part of the desert is found to contain 60 per cent. of quartz sand, 30 per cent. gypsum, and 10 per cent. carbonate of lime. In any rainless district, every plateau of sandstone, no matter of what extent, must inevitably be resolved in course of time into drift-sand. We know that a great part of the desert of Sahara consists of a substratum of sandstone; the Libyan desert certainly rests upon a line of sandstone; and the Black Mountains, once supposed to be basaltic, are found to be sandstone blackened by the presence of iron. The heights of Djebel Ghurian, to the south of Tripoli, are also formed of lime and sandstone. The parched arid plain of Hammada, between Tripoli and Fezzan, which slopes steeply to the south, rests on a vast stratum of sandstone broken in places by layers of clay mixed with gypsum, and of marl, above which is an upper crust of gravel and limestone. In the plateau of Asgar the sandstone rises 4,200 feet high, and on its summit lies a winding valley with a curious terraced formation of rock. The surface of the torn and broken sandstone, split up into the shape of pillars, looks like a wild forest scene carved in stone. The descent from the plateau leads through grand and picturesque scenery, the path winding its way through a narrow rocky gorge of singular wildness and beauty.

The ragged Tummo or War Mountains, intersected near Bilma by the



IN THE LIBYAN DESERT.

Straits of Mourzook, are composed of a surface layer of blackened sandstone. The black colour of the range is due partly to the decomposition of the rock, partly to the admixture of iron, and partly to the presence of real black basalt. Viewed as a whole, it has the appearance of a large "token."

Token is a name applied to certain risings of the ground, formed by the excavation of the softer ground round them by the action of wind and rain. The desert land in the south-western part of Algeria has also been found to contain large quantities of sandstone. Four distinct characters may be distinguished in this locality. First comes the wave-like undulations of the mountain land of the Tell; then the upper plateau of the so-called Sikh Sahara; thirdly, a hilly region, chiefly composed of sandstone, with sandy marl at the base, and containing numerous mounds of gypsum; and lastly, the open desert plain of the Sahara itself. On its borders, chalk and slightly rounded stone *débris* are found, which evidently have come to their present position from no great distance. The deposits of sand are in some places from eleven to thirteen yards high, the strata lying horizontal to the surface, and containing only river shells. The soil contains heaps of *débris* of the various kinds of rock found in the neighbourhood, and deposited at various depths below the surface. The sand consists of grains of quartz, carried along by the rain through countless channels hollowed in the red gravelly earth, and then driven still farther by the wind. The sandhills, or *aregs*, are highest in the south; for the wind blows generally from the north, driving the clouds of drift-sand before it.

The extraordinary development of sandstone and quartz, together with the rainlessness of the district, is the cause of the desert formation. The quartz of the crumbling rock produces only coarse or fine sand, which undergoes no further change, and is incapable of producing vegetable life. It is only when there is a sufficient quantity of limestone or gypsum near the quartz that under certain circumstances a soil favourable to the growth of plants can be formed. It is by these substances, aided by the winter rains, that the sandy region of the Algerian Sahara is changed into the fertile pasture grounds visited by wandering tribes. These fertile tracts of land are called *Kifar*, in contrast to the desolate stretches of pure quartz drift-sand known as *Falat*. Vegetation is invariably found in all places where the amount of quartz contained in the sand is diminished, and where there is not a total absence of rain.

Besides occasional rain, the cause of this vegetation is primarily owing to the retreat of the sand; and the same chain of cause and effect is seen in the desert of Gobi. Wherever the quartz sand has the predominance, there is an end of vegetation. In the north of the mountain range of Chiachu, the soil is generally found to be loamy, and strewn with fragments of rock; the surface is undulating, broken here and there by low barren hills and numerous salt plains. The vegetation is in direct relation to the rainfall. Scarcely has the rain ceased when the plants shoot up from the barren ground, and the desert becomes an oasis. The Mongols hasten up with their herds, and a scene of busy life wakes in the midst of the death-like plains, until the sun has drawn out all the moisture, the leaves turn yellow, and the oasis shrinks back into the desert sand.

We see then the sand of the desert plains is produced by two causes; first by the sea, and secondly by the disintegration of the sandstone plateaus. We will consider this second process a little more closely, as several erroneous ideas prevail concerning it. The causes which produce the decomposition of rocky surfaces are variations of temperature and the action of plants and water. The strongest influence is exerted by the changes of temperature which make the first attack upon the solid mass of stone; the rain follows up the assault; and lastly, the plants aid in the work, partly by their very life, and partly by the salts and acids which are developed from their decaying substance. In the desert, where there is an almost total absence of vegetation, the rocks have nothing to fear from this latter agency, but the action of the water and the changes of temperature are felt in all their potency. The desert presents many instances of the mechanical effects produced by sudden downfalls of heavy rains; perhaps the grandest example of the erosion caused by great masses of water in the lapse of very long periods of time is seen in the high plateau of the Asgar.

But however actively such streams of water may contribute to the development of rocky fragments and *débris*, the changes of temperature are far more effectual in the production of true desert sand. On the western shores of Lake Nyassa, Livingstone found fragments of rock so heated by the sun, that it was impossible to rest upon them even after sunset. The result of the cooling down which takes place through the night was that the upper surface of the stone was chipped completely off, and the traveller in his camp heard the rolling thunder of the bursting rocks, sounding like the blasting of stone in a quarry. The same phenomenon has been observed in the volcanic region on the western side of Damascus. The heat in summer is so great, that, on the unanimous testimony of the inhabitants, the black stones scattered on the ground are heard to break up with a loud report. The sun, therefore, in hot districts of the globe, can and does exercise a destructive effect upon the rocks, and no small part of the vast extent of rocky decay and wreck described by travellers in the south of the Algerian desert must be ascribed to the extraordinarily abrupt and sudden changes of temperature. Perrier found the dew frozen round his tent in the Algerian Sahara, on the 25th of May, 1840, at six in the morning, and five hours later the thermometer stood at 77° Fahr. in the shade, rising in the following three hours to 88° Fahr.

This very great change from heat to cold, with the sudden contraction and expansion which it produces, inevitably leads in the course of time to the breaking up of fragments of rock, and the wind then taking up the work of destruction, gives the torn masses no rest until they are reduced to fine drift-sand. The destructive effects of dry winds have been observed on the coasts of Norfolk and Suffolk, and they are found to be far more destructive than winds accompanied by heavy rain.

The continued action of the wind sweeping across the desert plains pursues the fragments of quartz, and pulverizes them into finer and finer sand, in proportion as they are carried farther from their native rock.

As to the extent of the desert region in North Africa, very faulty and inaccurate theories have obtained among the generality of people, and the area of the true sand waste (Falat) of Sahara is frequently supposed to be larger than it actually is. More accurately described, the great desert is known to be an archipelago of oases with scattered villages, surrounded by hills of fruit trees; principally date palms, but with no lack of pomegranate, fig, apricot, and peach trees. The herds thrive well upon the desert pasture-lands; but running water is scarcely ever seen, the life-giving element being found only in trenches laid down in the hollows of the plain. Only a small part of the Algerian desert is covered with sand, and the sandy districts are by no means the most difficult to travel through. The treasures of subterranean waters are very great, and play an important part in the legendary lore of the desert. In many places, for instance in the ruins near Reggada, one is said to hear the rushing of underground streams by laying one's ear upon the ground. The wells of the steppes begin to dry up at the beginning of summer, so that the inhabitants are forced to migrate northwards towards the Tell, whence they return at the beginning of the autumn.

In short, the real sandy desert is much smaller than is generally supposed. The open sandy sea to the north of Lake Tschad, on the road to Bilma, may be considered the heart or centre of the true desert. It is true that the plain seems boundless to the traveller, but it is in reality only the central focus of the desert. This plain of Tintumma is also dreaded from the difficulty of keeping in the right track. The senses are so blinded and deceived by the measureless plains of white sand, that even travellers long accustomed to the desert often lose their way. Perhaps the Hammadas, or stony plains, are even more extensive than the sandy wastes. The typical representative of the former is found in the scorching, waterless plains between Tripoli and Fezzan, where a patch of green is a great rarity.

The broken fragments of stone found on the Hammada are sharp edged, and have given rise to the idea that the ground on which they are found cannot have lain long under water, or the angles must have disappeared under the action of the waves. But the Sserir, the lower level, which seldom rises higher than fifty feet above the bed of the soil, which is covered with coarse gravel, or smooth, round, polished stones, speaks of a far longer submersion.

The most extensive tracts of true desert sand are found in the Libyan plains on the east of Sahara, and we have every reason to believe that it is also the oldest part of the complex desert system of North Africa. Wherever, under the joint influence of geographical configuration, geognostic construction of the soil, and meteorological action of the atmospheric air, a desert growth has once begun, it cannot stand still, but is forced to advance in continual development as long as the existing causes continue in force. And thus we see, not only, as in Egypt, the gradual extinction of once great centres of civilization beneath the advancing sand, but also the disappearance of the

SAND STORM IN THE DESERT.

cultivated regions of the far East in the desert of Gobi, beneath the gloomy storm clouds of drifting sand, which has, as some believe, buried in the lapse of ages many a flourishing city. The process of desert formation has by no means been played out in some former geological epoch; we are not looking upon it as some completed work of the past; it is day by day working out its career in the present. As the burning air has dried up in past ages all the isolated arms of the sea and inland lakes, so it continues at the present moment to lessen the diminished water supply, a fact which has not escaped the attention of the Nubians of Kordofan. "In the days of our fathers," they tell us, "the pools of water were twice as large as in our day. We only needed then to dig down for a few feet to be sure of finding water, and now we are forced to dig three or four times as deep, and find but little."

We have incontestable evidence of the fact that parts of Sahara lay once at the bottom of the sea, in the presence of the salt deposits found in the desert. But this former water bed was by no means connected with

FOREST ON FIRE.

the ocean as a whole. Arms of the sea which are cut off from the ocean bed by the undulations of its level become mere salt beds by the great evaporation; indeed, the same may be said in a measure of all inland lakes which gradually evaporate away. If therefore, as is distinctly proved by the remains of former vegetation found in large tracts now utterly desolate, the desert of Sahara had at one time a much larger wealth of water than it has at the present day, the lost inland lakes must also have left traces of their existence in certain salt depressions of land, and close investigation will be necessary in every case to determine whether they were lakes or seas. This point deserves special attention; for if it had been duly taken into account, the present generally received notion that the desert of Sahara was once washed by a large, uninterrupted ocean, would never have become so widely spread. It is only true of narrow tongues of land extending from the great Syrtis to the oasis of Sivah, and of certain other places; but it never was true of the desert taken as a whole. Salt is as characteristic of the desert as the sand; there is no desert land, indeed there is no sedimentary formation whatever, without salt, although its distribution over the surface varies considerably in amount in different places. It is remarkable that the geological age of the desert salt is never very considerable. While the rock salt of the Khirgis steppes belongs to the lias age, the salt of the Sahara originates in the diluvial period, and that of Algeria in the chalk period. The salt deposits of the Gobi are also of recent date; indeed, the whole desert of Gobi is far behind the stage of development which the Sahara has reached; either because the process of formation was not initiated until a later day, or because the desert-forming agencies work with less intensity.

Plateaus and Mountains.

In bold, grand contrast to the horizontal levels of the plain extending over so large a portion of the earth's surface rise the mountain chains, with jagged peaks and massive outline towering into space. It is true that their mightiest upheavals are insignificant when compared with the continents themselves; but the actual importance of the mountain range is not lessened by our having to regard it as a secondary phenomenon in comparison to the great sockets of the continents. We have already shewn that the origin of mountains, a problem which has for many years exercised the acuteness of geologists, is probably due to the contractions of the earth's crust. Dana was one of the first geologists who put forward the theory that the origin of our mountain system is due not to an upheaval consequent upon the radiation of forces working from the centre of the earth, but from the lateral displacement of great masses of the earth's surface. Together with this view, and on the assumption that an unequal contraction of the earth's surface takes place, even the uprising of continental masses becomes more intelligible; and it is more readily understood how parallel ranges like that of the Erz Gebirge, and upheavals like the massive heights of Scandinavia, can be formed. These theories have been illustrated by experiments undertaken first, but only imperfectly, by Hall, in the year 1813; and more accurately by Fabre. The materials contracted by Hall were placed upon an unyielding basis, while Fabre placed strata of clay on layers of caoutchouc lying one above the other, the contraction of which appeared analogous to the contraction of the upper strata of the earth.

A still more interesting experiment was made by Chancourtois, to exemplify the uprising of the mountains during the process of the earth's surface contraction. He plunged an india-rubber balloon, inflated and fitted with a copper tube and cock, into a bath of wax. When the balloon was covered entirely with a coating of wax, a little air was allowed to escape through the tube. The shrunken balloon immediately produced upon the uncontracted surface of the wax depressions, elevations, and furrows which successfully imitated the form of the earth's relief. Of course experiments like these are always faulty on some side or other, but they gain in interest and significance when they run parallel to attentive experiments made upon nature herself.

Such an experiment has been recently attempted by Heim in the neighbourhood of the springs of the Reuss, the Linth, and the Rhine, and they have greatly facilitated our comprehension of the mechanism of mountain formation. The very fact of the striking parallelism found in the great mountain ranges, and seen most clearly in the Alleghany Mountains and the Jura range is very significant, especially when it is found that no intersecting of mountain chains is known to exist.

Another characteristic which paved the way for the modern theory is the fan-shaped structure of the central masses of the Alps. A second question, and one not too easily answered, then presents itself; namely, whether the central mass, as a partially eruptive formation, had an active part in the upheaval of the Alps, or whether, like the sedimentary deposits, they were passively distributed. The result of Heim's observations establishes the conclusion that the uplifting of the Alpine chain was not the result of eruptive rock; for the eruptive rock of the Alps is much older than the upheaval itself, and has been passively brought to its present situation; besides which, eruptive rock never produces mountain chains. The inner structure of the central mass speaks for the "crease or fold" formation. Crystalline rock is often so bent and curved by its contact with the sedimentary strata, that it follows more or less closely the position of the latter. Stripes of rubble, breccia, and other proofs of displacement are frequently met with. The sedimentary strata often found in unexpected positions, and closely resembling crystalline strata, not only follow the flanks of the central mass, but penetrate deep into the interior, and take part in its formation, without shewing signs of any other force than that of purely mechanical metamorphosis. These sedimentary shreds are the remains of closely compressed, and here and there absolutely crushed, troughs or furrows, and are not detached and broken fragments. Part of the central rock itself is made up of them. Central masses, then, says Professor Heim, are wrinkles of the earth's crust. All these masses, all the limestone range of the Alps, have formed themselves, because, working together within the limits of the upheaval, they were forced of necessity to neutralize any tangential displacement. If one wrinkle or fold was narrower than the rest, another necessarily became wider. All the numerous and beautifully varied peaks are the product of the same power and of the same time, whatever may be the difference of age of the material out of which they are built. They are probably the effect of the power of gravitation, which was able to overcome the solidity of the rock, and to throw up folds while it brought the rest of the earth's crust scarcely one hundredth part nearer to the central point.

Upon an examination of volcanic ranges it is clear that their origin is connected with a new formation of rock, and that the range was gradually formed by the heaping up of the separate mountains. Other mountain chains are formed by the displacement of rocks already existing; with them the range is the first in order of creation, and the separate peaks are modelled out of it by the decay of its surface.

Heim found this modelling process to be of much greater extent within the district investigated by him than was previously imagined. A close inspection of the situation of the valleys and crests, he says, and of the interior formation of the range, shews that the present surface formation is chiefly the result of denudation, upon which the interior construction and the original clefts have but little influence. We find longitudinal valleys where ridges were expected, and the transverse crests are placed in defiance of the interior construction of the central mass. Generally within the inner zone of the central Alps the volume of the present mountain may amount to about the half of that of the range first cast up above the level of the sea; the other half has been washed away and worn down. The mountain has been laid bare to such a depth, that no surface formation produced by subterranean force can any longer affect it. In perfect accordance with this statement is the result of an examination of the central Alps of Graubunden and the Tyrol, which shews that the transverse valleys intersecting the mass of the Ferner and the Venediger are not extensions of original clefts, but the effects of erosive force.

No credit is now given to a former theory, which supposed that at the time of the folds or wrinkles being formed the rocks were soft and plastic. The folding process and the corresponding mountain formation has absolutely nothing to do with the composition of the rock; the one is entirely independent of the other.

But when, basing our conclusions upon what has been said, we attempt to construct a perfectly satisfactory theory of mountain formation, we are met by the difficulties connected with plateaus or high plains. Are we to assume that the great plateaus, such as Pamir, "the roof of the world," are also formed by contraction and displacement? It seems not altogether improbable, when we remember that the most important mountain range in the world is found in close proximity to this vast mass. Or may it not more probably be the old-world boundary line of the continent, once washed by the sea which rolled in past ages over the Turanian plains? We do not attempt to decide the question; for, in the absence of sufficient data, any attempt at a decision would only swell the number of hypotheses. But it is as well to call attention to the difficulty, if only to shew how many lessons have yet to be learned before the prize of a perfect comprehension of all the laws and processes of mountain formation may be won by the eager student.

There is one remarkable fact which deserves to be mentioned while treating of this subject; namely, that, as a rule, highlands and mountains are the predominant characteristics of equatorial regions and lowland plains of the poles. It seems as though the form of the globe at the equator, corresponding to the upward impulsion of the masses of the mainland, had favoured the development of high rising ground. But a glance at a map of the Pacific Ocean, whose greatest area is found within the equatorial regions, warns us to be cautious in ascribing to a universal law what may be only the result of an accidental combination of various forces. In any case we certainly find, thanks to the mountains and plateaus, all the climates of the earth represented within the limits of the torrid zone. We find that from the lofty peaks close to the equator itself great avalanches thunder down into the valleys beneath, while at the foot of the mountain the plants and animals of the tropics thrive in the steaming sultry air; so that the high lands carry the north into the midst of the south, and bring all the climates of the world, and every season of the year, into close proximity.

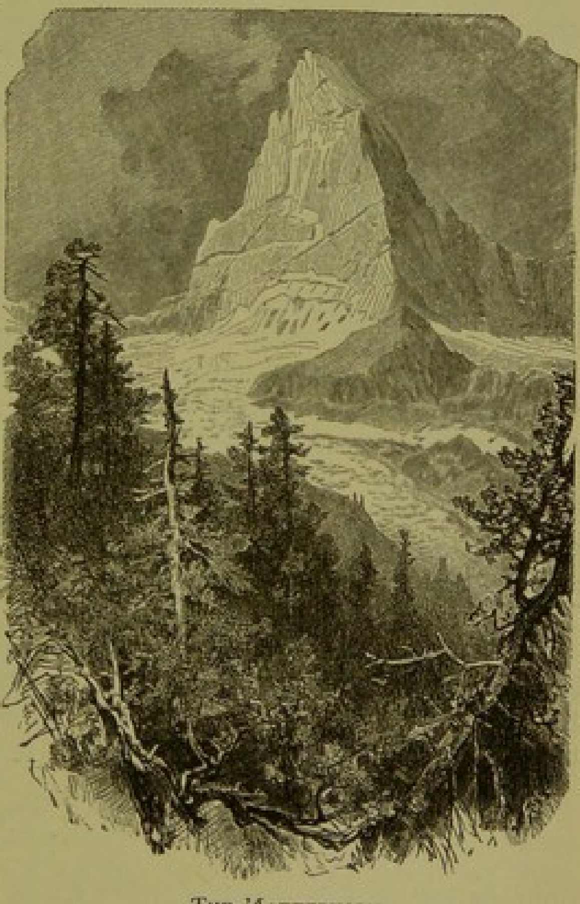
The transition from the plain to the plateau is formed by *terraced* land, which, however, is not often found arranged in clearly defined terraces one above the other. They are, as a rule, intersected by mountain chains more or less parallel one to the other; and very frequently the mountains themselves are not connected into a perfect chain, but are seen upon the rising ground which leads to the high plateau, scattered in unsymmetrical confusion.

The highest part of a mountain chain is called the crest or ridge, although the true ridge is more rarely found than might be supposed. The Thuringian forest in Germany presents a good example of a real mountain ridge. It forms an uninterrupted, undulating line, traced out by the old *Rennsteig*, or boundary path, and extends sometimes as a narrow path, and sometimes as a wide carriage road, for more than ninety miles, affording in many places a view of the plain on both sides.

Mountains are divided into high and low, according to their height above the sea level, the high mountains including all that are more than 7,000 feet in height. The lower mountains have, generally speaking, softer outlines; the higher are more rugged and precipitous, with desolate, inaccessible walls, leaping cataracts, and valleys strewn with broken rocky fragments. The bare peaks, often covered with snow, rise above the clouds. If the measure of the mountain be taken less from its height above the level of the sea than from its horizontal extent, the contrast between mountain chains and passes becomes more clearly apparent. The Ural may be taken as a type of the former, and the Hartz of the latter. Sometimes, as on the Pacific slope of the Cordilleras, the mountain chain appears as a perfect wall of rock, and sometimes its ascent is scarcely perceptiple to the approaching spectator. This is the case with the Ural chain, when crossed from Perm. The slopes, both on the European and Asiatic sides, are so gradual, that the traveller looks upon them rather as pine-clad heights than as a great mountain chain.

The highest point of a mountain is called the peak, and the lower parts are known indifferently as saddles, yokes, and passes. The readier of access these passes are, and the nearer they are found to the base of the mountain, the more easily a communication between both sides of the chain may be carried on. Thus the Alps are the most accessible of all high mountains. Their most convenient passes are found half-way between base and summit, while in the Pyrenees and the high mountains of Asia and America they are much higher. The greatest height of a mountain peak stands in no simple proportion to the height of the ridge, but the height of the ridge is closely connected with that of the passes; so that the average height of the one may be regarded as the average height of the other. Van Sanklar, in his investigations of the Alps, speaks also of an "average socket height;" that is, of the height of that portion of the range which forms the true ground mass on which the ridge and separated peaks rest. In the Oetzthal Alps, Van Sanklar gives this "socket height" as less than the half of the average ridge height.

The outer form of the peaks is very various, depending upon the height and age of the mountain, the stone of which it is composed, the manner of its formation, and the atmospheric conditions surrounding it. These various circumstances admit of such endless differences of combination, that almost every mountain has a special physiognomy of its own. What a contrast is presented between the easily ascended height of the Brocken, and the shallow rocky cone of the Schneekuppe, and the tapering peaks of the lofty Tatra chain! or again, between the undulating curves of the Thuringian mountains and the giant spires of the Andes, rising above their frowning wall of rock. And we have not even mentioned the volcanic mountain, which belongs to quite a different class of formation. In many descriptions of mountain scenery, we read of needles, teeth, and horns, words which strive to give some faint impression to the untravelled reader of the wonder of a mountain peak; but he who has never had the good fortune to see for himself the Matterhorn or the Pic du Midi can form but a vague, unsatisfying idea of the grand, savage beauty of these noble rocks. The grandeur of any particular mountain depends but very slightly upon its height above the level of the sea. The giant mountains of the Himalaya, when seen from the plateau of Thibet, do not produce so striking an impression as the peak of Teneriffe, when seen from the sea, its rocky head breaking through the veil of cloud.



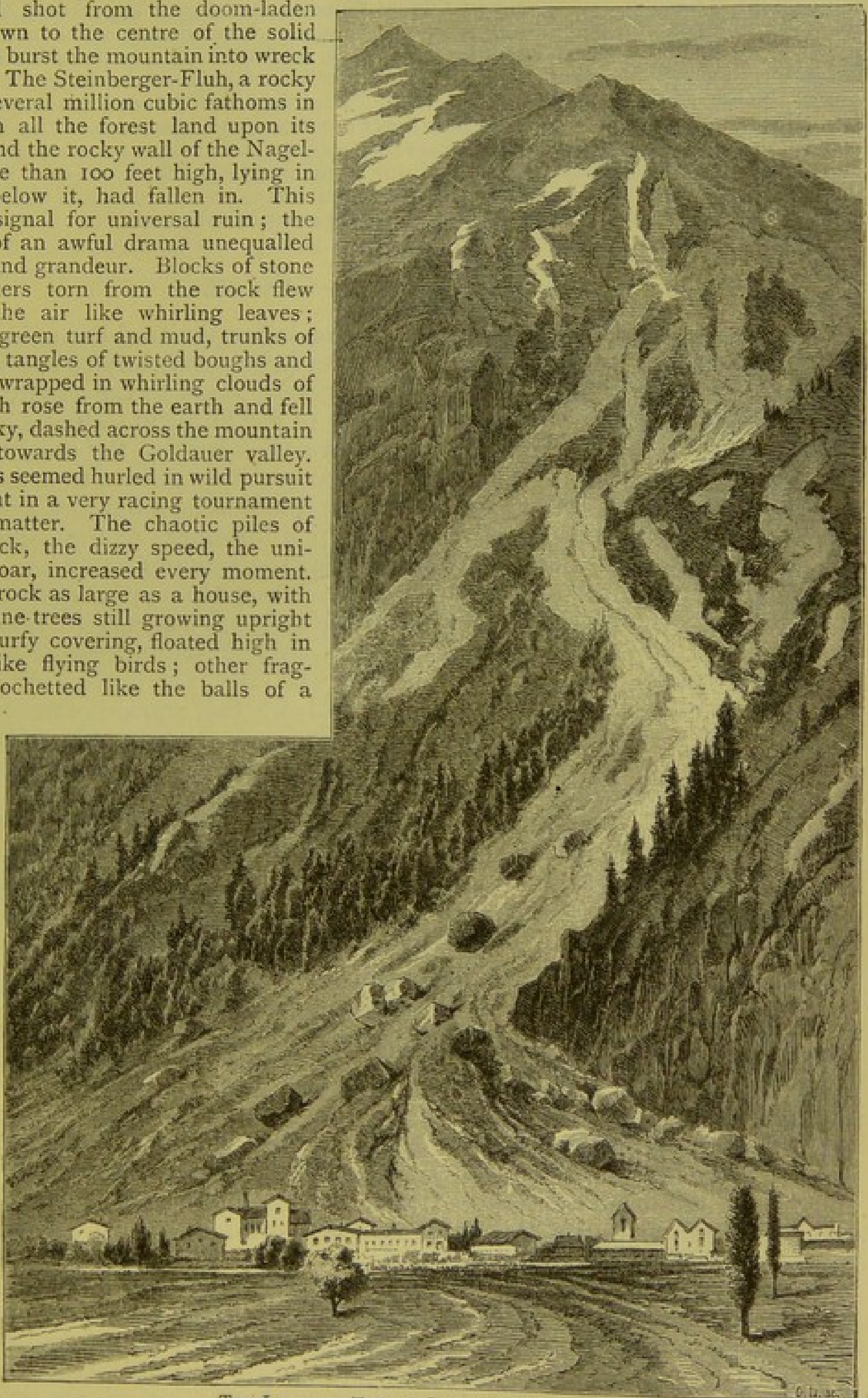
THE MATTERHORN.

The modelling of mountain ranges and the formation of valleys are closely connected. When elevations were first formed on the earth's surface, valleys appeared between them as necessarily as shadow follows light; but these primeval valleys have long since disappeared in their original forms. For, as we have already shewn, the waters of the earth have never rested in their work of effacing the ancient landmarks, undermining the base of rock, and filling up the valleys by deposits of *débris*. The process of valley formation, in so far as it was caused by erosion, has been divided into permanent formation, which will never cease so long as there exists *relief*, or raised ground, and water; and into those numerous cuttings where modifying agencies individualise the process in their own way. The formation begins always at the base of the mountain; and the valley, so far as it is the creation of erosion, grows from that point backward toward the centre. Wherever the mountain range stands in regions where the volume, distribution, and form of the rainfall and the distribution of temperature are unequal, the valleys extend in time across stretches of land where these modifying factors act very unequally, and the slight degree of uniformity of the strata makes it highly probable that in course of time it will come in contact with vertical or horizontal layers of stone of different chemical or mechanical resistance. All these circumstances give an individual stamp to every succeeding portion of the valley, because they alter the mechanical momentum in every separate locality. As a rule, a valley within the region of perpetual snow will pass through three stages of different mechanical energy; first, relative rest or minimum of action under the cover of ice and snow; second, maximum of action in certain times of the year on both sides, but more especially on the lower limit of their covering of snow; thirdly, concentration of action during the whole year along the various channels of brooks and rivers below the snow.

At the first glance the observer is apt to under-estimate the action of air and water upon the solid rock. The mountains of which mention is made in the earliest historic records still rear their lofty heads. More than thirty centuries have gone by since Moses gathered together the children of Israel round the foot of Sinai, and the massive rock still rises as of old to meet the blue splendour of the sky; and to-day, as in the times of the Greek heroes, Stromboli is the light of the Tyrrhenian Sea. It is only with the aid of science that we are able to recognize the grand changes taking place around us, changes which are hardly perceptible in the course of centuries. And yet there have been moments in which the undermining, solvent power of running water has changed in an hour the face of mountains. This happens sometimes when rocks resting upon a steep slope of clay are set in motion by the softening of the mass beneath them, and the terrible catastrophe of a land-slip occurs. Nothing is more awful than to see the mountains which we regard as the very types of stability begin to tremble and slip from the strongholds where we thought them rooted in the very foundations of the earth. Trees and fields are torn down in their fall; dwellings, human life, all that lies across their downward path, is buried beneath the crushing weight of rock. Happily these catastrophes are of rare occurrence, and seldom happen without warning signals of their approach. Generally smaller fragments precede the descent of the great masses; blocks are loosened from the mountain-side, clefts burst asunder in the ground, and the old rocky slopes bend and sway. But if the inhabitants have not then obeyed the signal and taken to flight, their doom is sealed; for when once the great mass itself is set in motion, it is too late to think of escape. In a few minutes all is over. Thus, on the 4th of September, 1618, the inhabitants of Plurs, near Chiavenna, were overtaken by the fall of Monte Conto, and more than 2,000 human beings were buried alive by the ruins. A chestnut wood now stands above the scene of terror. And nearer to our own times is the terrible disaster of the fall of the Roszberg, near Goldau, in 1806.

A quarter to five had just chimed from the church tower at Art when a large rent opened in the earth half-way up the softly sloping mountain-side near the Rüthi-Weide, and grew wider, longer, and deeper every minute. The grassy slopes on each side turned completely over, exposing the brown lining of earth like a field turned up by the plough. At the same moment the adjoining wood seemed alive; the high crests of the slender firs swayed as if moved by an invisible hand, just as a field of half-ripe corn bends under the summer wind. This wave-like motion grew and spread in ever-widening circles; the rhythm became irregular and broken; trunks and crests striking against each other in wild confusion. With hoarse screams, ravens, rooks, ~~jackdaws~~, and other forest birds fled in wild haste to the forest slopes of the Rigi-Berg. And now the advancing shock and swaying, the billowy rise and fall, had reached the mountain-side, which looked as if giant moles were burrowing underneath the surface. At the same time began a slight ever-increasing gliding and slipping down of the whole upper surface, gaining every moment in strength and speed. The fir plantations resisted, and, forced to yield, looked, as was said by those who watched the awful scene from beginning to end, like hair combed back from the roots against its natural growth.

The horror-stricken spectators then saw the circle of destruction widening farther and farther, till meadows and orchards, fields and farm-yards, with stabling, cattle, and men, were drawn into the fearful descent. The people who felt the ground on which they had been born and grown up slipping away from under their feet rushed in terror from their houses, to escape the horror round them. Then all at once a thunder roar, as if the very pillars of the earth were uprooted, a rattling, cracking crash, as if a thousand-forked sheaf of lightning had shot from the doom-laden clouds down to the centre of the solid earth, and burst the mountain into wreck and ruin. The Steinberger-Fluh, a rocky mass of several million cubic fathoms in bulk, with all the forest land upon its surface, and the rocky wall of the Nagel-Fluh, more than 100 feet high, lying in terraces below it, had fallen in. This was the signal for universal ruin; the first act of an awful drama unequalled in terror and grandeur. Blocks of stone and splinters torn from the rock flew through the air like whirling leaves; shreds of green turf and mud, trunks of trees, wild tangles of twisted boughs and stems, all wrapped in whirling clouds of dust, which rose from the earth and fell from the sky, dashed across the mountain precipice towards the Goldauer valley. Fragments seemed hurled in wild pursuit of fragment in a very racing tournament of brute matter. The chaotic piles of broken rock, the dizzy speed, the universal uproar, increased every moment. Pieces of rock as large as a house, with the tall pine-trees still growing upright on their turfy covering, floated high in the air, like flying birds; other fragments ricochetted like the balls of a gigantic cannonade, rising in wide curves, crashing from time to time against some other flying mass, and breaking up like the sparks of white molten iron beneath the blow of the hammer. It was a scene from the Titan wars of the old Greek myth.



THE LANDSLIP (?) NEAR BILTEN IN SWITZERLAND.

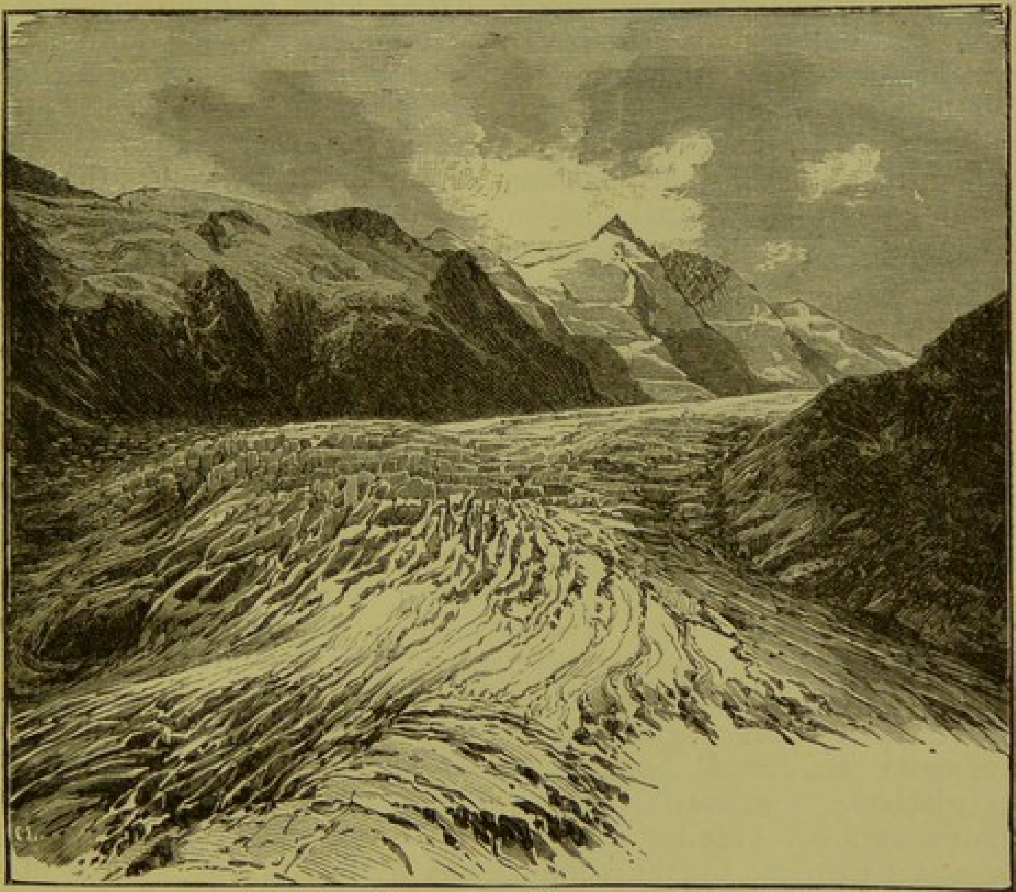
Within a few minutes, more than a hundred dwelling-houses, and as many stalls and barns, were destroyed; for the whole slope of the Roszberg, nearly as far up as the highest peak, crowned by its great wooden cross, was covered with houses, and in the valley below lay the rich hamlets of Goldau, Busingen, and Lowerz, between the lakes of Lowerz and Zug. Four hundred and fifty-seven human beings found a common grave beneath the fallen rock. For many years the whole country round lay dead below its dismal ruins, as if smitten with some mysterious curse; fragments of torn rock lay in the traveller's path at every turn, and reminded him of the terrible 2nd of September, 1806. Time has now softened the impression of desolation, and a tender veil of moss and flowers is drawn over the scene. The rocky fragments are overgrown with moss and fragrant saxifrage; dark-blue campanula and milk-white clover wave among the tall grasses rising from between the fallen *débris*. Shrubs and plantations of young fir trees shadow the scattered blocks of stone, and in years to come nothing but a few vague outlines will remain of the great burial place.

THE SNOW LINE—GLACIERS.

The snow line is the name given to the lower limit of the fields of perpetual snow. In the districts near the poles it is found close to the sea level, and in every other latitude, from the temperate zones to the equator, it runs at varying heights according to the climate of the locality; so that even in the torrid zone there is at a certain height above the sea level the same temperature which prevails at the poles. Not that we may picture to ourselves the snow line as a fixed line rising in regular gradations from the pole to the equator; on the contrary, its height even upon the slopes of the same mountain range varies considerably. In the Alps the summer snow line is found about 8,000 feet above the sea, and yet there are Alpine peaks of 11,478 feet in height, and of gently inclining slopes, which are entirely free from snow. Even in Nova Zembla, which possesses the coldest summer in the world, the snow line does not literally reach the sea level; for during the summer the plains and fields are partly uncovered by the snow. The height of the region of perpetual snow along a mountain range depends on the distribution of heat through the seasons of the year, on the greater or less dryness of the air, the character of the prevailing winds, the volume of snow falling throughout the year, and the vicinity of wide heat-radiating plateaus. Each of these factors exerts considerable influence upon the position of the snow line, and may raise or depress it by several hundred yards. Thus we find the region of perpetual snow upon the Andes at Quito, just over the equator, marked by a line running at the height of 15,820 feet; in the western Cordilleras of Chili, between the 14th and 18th degrees of south latitude, 18,360, probably on account of the greater dryness of the atmosphere. The snow line of the Himalayas presents a great contrast on its opposing slopes. On the south side of the chain the line is found 15,500 feet above the sea level, and on the north side 19,560 feet, owing to the nearness of the cold plateau of Thibet. These inequalities are generally to be ascribed to the varying moisture of the atmospheric currents. While upon the southern incline of the Himalayas the vapour-laden monsoon rises to pour down its moisture in the form of snow and rain, according to the height of the mountain, the northern slopes are swept by the dry winds known by the name of "snow eaters."

The dazzling snow fields of the higher mountain ranges would inevitably grow indefinitely in extent if they were not partially carried down into the valleys. In storms of wind the peaks seem enveloped in clouds of whirling snow, which is driven down to a lower level, where they cannot exist as snow; and great masses are carried down to the valleys by the avalanches of the spring and summer months.

We said, in writing of the breaking-up of icebergs in the polar sea, that a very slight shock was sufficient to hasten on the catastrophe, and we find that in the Alps the weak touch of a bird has been known to give the first impulse to an avalanche, whose final effects were terrific and disastrous. At first the mass of moving snow is but slight; it glides down the precipitous slopes above the more solid layers, but rapidly increases in extent and velocity. Ever-widening circles are drawn into the descent; they stretch out hither and thither, until a wide white plain, sending up clouds of whirling snowflakes, is seen tearing down in headlong flight to the plains below. Even the air is carried along in its downward career, in one place condensed, in another expanded; the atmospheric waves meet and clash, tearing up large trees, and hurling down fragments of rock.



THE GROSZ GLOCKNER AND PASTERZEN GLACIER

The dry powdery snow of the upper fields is soon changed by surface-melting and freezing up again into hard granular masses or glacial snow, found in more or less clearly defined layers, and in great hollows excavated in the snow bed. Enclosed by mountain slopes, which keep up the supply from year to year, it accumulates in the hollows of the snow for centuries together, and forms the true source and fountain of the glaciers. These great streams of partly frozen snow and ice are often several miles long, and glide in uninterrupted motion towards the valley, where the rising temperature puts an end to their advance.

The glacier ice is made up of a mass of melted crystals and bubbles of air, crossed with myriad hair-like rifts, and a general stratified formation. On a flat ground the surface of the glacier appears curved; and on uneven, irregular ground it is intersected with crevices, some widening upward toward the surface, and some downward toward the rock. New crevices are continually opening in the same place, slipping forward and closing up again, while a fresh group is formed in the place they have just quitted. On the selfsame spot of the Mer de Glace, where Saussure first discovered the star-shaped radiating crevices, they are seen at the present day, closing up again below the original spot. Out of the wildest confusion of ice peaks and spires the glacier accumulates and becomes a connected mountain.

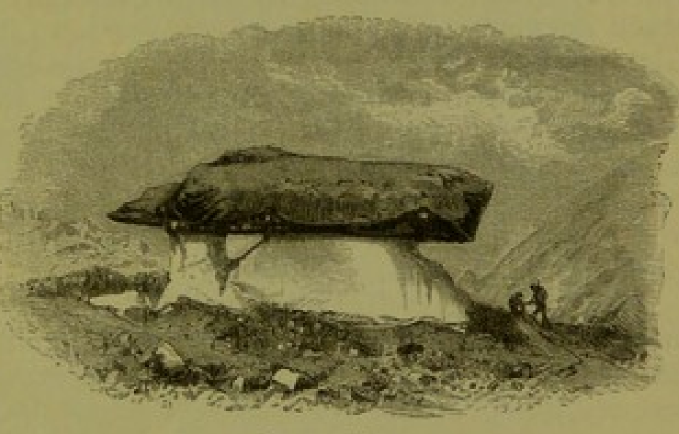
It is very rarely that the original rock can be seen through the open crevice of a glacier. The snow-water pours down the opening, and when the crevices are closed they leave behind them those chimney-like openings excavated by the water, which are known as glacier mills. Natural water channels and caves are found below the bed of the glacier, some of them being of very great extent. Indeed, it is said that a mountaineer who fell down a crevice at Grindelwald, 390 feet deep, worked his way under the ice to the foot of the Wetterhorn, where he came out above ground. The glacier streams generally flow out from cavernous openings on the lower edge of the glacier.

While the ice is constantly making its way down the valley, the crevices always appear in their original position. The gliding, slipping movement of the glacier arises from the pressure of the collected mass and the elasticity of the ice; it is greater in summer than in winter, and by daytime than during the night. In the centre, on the surface, and down steep inclines, the advance is more rapid than near the edges and below the surface along more level ground. On an average it amounts to twenty inches daily.

The most rapid advance known (13 yards) was observed on the Vernagt glacier in Switzerland, on the 1st of June, 1845. The Vernagt and the Rosenthal glaciers, previously separated by a ridge of rock, suddenly united, and hastened, with sharp cracks and shakings of the rock, down toward the valley. On their descent they were stopped by a projecting ledge of rock, where they lay piled up, stopping the course of several mountain torrents, and turning them into a lake. In less than fifteen days the waters of the lake had eaten right through the glacier, and, breaking out on the other side, laid waste the whole valley as far as Innsbruck. Sometimes the glaciers break up on sharp ledges when the incline is very steep; great masses are split off from the central bed, sometimes giving rise to the formation of smaller glaciers. On the fall of the Bies glacier, which broke from the Weiszhorn, and fell into the Nicolaithal, in the year 1819, the village of Randa was destroyed by the compression of the air, and a mass of more than 12,000,000 cubic yards of ice was heaped up on a surface previously entirely free from ice.

The stones, dirt, and rubbish, which mark the surface of glaciers, extend (owing to the movement of the ice) in long rows along the edge of the glacier, and are called *lateral* moraines. When two glaciers unite, the joining margins form a *medial* moraine, while the accumulation of rubbish at the foot of the glacier is the *terminal* moraine. Masses of rock which sink below the glacier through the crevasses are crushed into powder by the immense weight and forward movement of the glacier, and occasion the turbid state of the glacier streams.

It has been proposed to sink shafts down certain parts of the glacier beds, and to examine the surface of the rock buried beneath them. The proposition deserves careful consideration. De Candolle put forward the question some time ago, whether the remains of organic life, dating from a period preceding that of perpetual snow, might not be found beneath the icy covering of the Alpine peaks. There is every reason to believe that, before their entombment under the present masses of snow, the Alpine heights were covered with vegetation, and it is probable that even their highest peaks were the scene of animal life. The only question is whether this vegetation was not lost before the peaks were covered with snow. But even if this were so, the remains of the organisms would still be found. The question as to whether there is any chance of discovering the remains of prehistoric plants and animals beneath the snow, and the condition in which they would be found preserved, is fortunately easier of solution than any which concerns any other fossil organisms. If a dead organised body is to remain unchanged, it is necessary that it should be protected from chemical or mechanical destruction. In the first instance, a temperature approaching or sinking below zero is the best method of preservation, and the proof that its effect is not diminished by the lapse of ages is found in the fossil remains of the old-world mammoths found in the arctic ice. Chemical decomposition takes place by the agency of microscopic plants, as fermentation, rot, and corruption; and preservation by means of intense cold is effected by putting an end to the vegetating growth of plants. Of course, when this growth ceases, there may be still a certain decomposition effected by oxygen. But this is, generally speaking, very slight and inconsiderable, and moreover a layer of mountain snow twenty feet thick, and hermetically closed, is a very good protection. We may therefore leave the influence of oxygen out of the question, and assume that antediluvian organisms buried beneath the eternal snow are perfectly preserved, even in their most delicate parts, and that plants not only keep their blossom and fleshy fruit, but also the more durable of their colours and odours. This, we think, however, would only occur in the case of a sudden covering of ice; but, if the surface were gradually frozen, very little vegetation could be perfectly preserved.



Glacier Table.

Owing to the surface-melting of the glacier ice, substances which have been buried for some time within its bed gradually come to the surface; for the glacier ice cannot tolerate the permanent presence of any foreign substance within it, but sooner or later ejects it. If the imprisoned substance is of any considerable size, such as a piece of rock, it may under certain circumstances rise above the surface of the ice, having the effect of a sunshade, which keeps off the warm rays, so that the icy surface on which it rests is preserved, while the glacier all round it is melting away. In this way glacier tables are formed, stones resting on pinnacles of ice, some of which are several feet in height. On the Theodule glacier there are flat tablets twenty feet long and six wide, resting on thin feet of ice; and on the glacier of the Aar the supports of ice are more than seven or eight feet high. Of course this icy pedestal has but a comparatively transient existence; the sun's beams destroy its base, especially upon the side facing the noonday sun, and at last the tablet falls down, the old base melts away, and a new one begins to form. The process can be repeated several times during the downward journey of the glacier, until the rock finds rest at last in the valley beneath. In the valley of the Saas a serpentine block 8,000 cubic yards in volume is called the Blue Rock, and is known to have been wandering with the glacier of the Mattmark over the ridge of the mountain in the year 1740. Nothing is more singular than the appearance of these glacier tables, and nothing so easy to understand as the method of their formation. They recall the remarkable "earth-pyramids" arising from the effects of erosion in heaping up masses of clayey and sandy rubbish round piles of stone and broken rock. The masses of rock act like the tablet on the glacier, as a protection to the earth beneath, and thus in course of time a column of earth is raised, with a stone slab on the top. In the glacial *débris* near Bozen, in South Tyrol, such columns are very frequently seen, and are sometimes more than ninety or one hundred and five feet high.

As the rise of temperature puts an end to the downward progress of the glacier, it is clear that this progress must vary considerably from year to year, and that the glacier must alternately advance and retreat. This is in fact the case. The romantic Gorner glacier shews this change of position very clearly, and in a way not very agreeable to the inhabitants of Zermatt. For the last fifty years it has acted like a feudal tyrant, has not only trodden down beneath its heavy foot the beautiful Boden Alp, but dashed into cornfields and rich meadows, licked up with insatiable tongue all the fertile coating of earth down to the bare rock, and rolled down before it stone, rubble, and dirt in wide moraines. Devastating the country round more than three-quarters of a mile in extent, it has wrought serious ill to many a peasant of Zermatt, especially to the owners of the meadows. Not only a large number of barns and stalls, but even several dwelling-houses, have been forced to yield to its approach. Indeed, it has been roughly calculated that if its advance continue, it will reach Zermatt itself in about forty years. Like all other glaciers, the Gorner Gletcher is gradually retreating and diminishing. But the moraines and piles of rock it leaves behind effectually prevent all cultivation of the soil. Since it began to decrease, the glacier has retreated 170 feet, which would be so much ground gained to the inhabitants of Zermatt, if it were still capable of cultivation. For several years past it has been noticed that corn was reaped from one half of a field, while the other half was taken possession of by the glacier.

The glaciers of Chamounix are also decreasing. Tourists revisiting that lovely valley are struck by the diminished size of the Mer de Glace and the Bosson. Apart from temporary checks occasioned by a winter of unusual severity, this decrease has been noticed for the last fifty years. But in striking contrast to the decrease of the glaciers of Mont Blanc is the great advance of the glacier on the northern slope of Monte Rosa. Investigations have been made along all the ice fields of the Orteler group, and confirm the fact of the decrease in the glaciers; a fact noticed by all the inhabitants of the neighbourhood. In the unusually rainy summer (for the South Tyrol) of 1868, says Payer, it happened that the ice fields of the Orteler Alps, with whose extent I had become familiar in many previous visits, were worn away almost out of all recognition, and that in spite of the extreme severity of the preceding winter. Similar reports come from all the Alpine districts. Is there not some ground for the supposition that our ice world is hastening to its end with accelerating rapidity, and that the increasing polishing of the glacier track is the principal reason of the change? If all the glaciers at present in existence were to disappear, there seems reason to believe that a renewal of ice formation would certainly begin, but that the maximum area it would reach during a long series of years would be far less than that covered by the glaciers now existing, because our present glaciers are only working with the diminished stock bequeathed to them by the so-called glacial period. The balance of temperature then imparted to them, and which they are only slowly losing, no longer corresponds to the general proportions of the heat at the height in which they are found; and accordingly their extension of area is no longer in proportion to the present momentum of temperature.

This theory is plausible, especially when we consider the indisputably greater extent of the glaciers in past ages, of which we shall speak more at length presently. There are no grounds for supposing that the extent of our present glaciers has restored the equilibrium with the proportions of temperature of those times.

If we cast a rapid glance on the present geographical extent of glaciers, we find that they are greatest in the far north. The whole of Greenland is covered by one vast glacier, which must be enormously thick, covering as it does an area of more than 320,000 square miles. Only a few peaks project from this cuirass of ice. The glacier descends in five great channels to the west coast. The largest is the Humboldt glacier, which is forty miles wide and 220 yards deep, where it throws itself into the sea. Iceland, Spitz-

GROSZ GLOCKNER AND JOHANNISLAY.

bergen, and Franz-Josef Land have glaciers of immense extent; as also has the island labyrinth of the American arctic seas. The Norwiegan snow fields are of great extent; one of the largest ice tracts extends from Sognefiord northward to the Jostedalsbra, from which numerous glaciers issue, of which the Nigar is the most accessible. The Alpine glaciers cover a space of about 960,000 square miles. The chief glacier beds being found on Mont Blanc, Monte Rosa, the Bernina, the Jungfrau, the Finsteraarhorn, and the Oetzthal and Stubay groups. The Pyrenean glaciers are far less extensive, and do not descend far down the mountain slopes; and the glaciers of the Caucasus are still more inconsiderable. The glaciers of the Himalayan range, on the contrary, and those of the Karakorum, are of immense size, as are those of the Altai.

In the far north of America there is a glacier near Kotzebue Sound covered with a layer of clayey soil, and similar glaciers exist on the southern point of America. The Alps of New Zealand have also a large glacier formation.

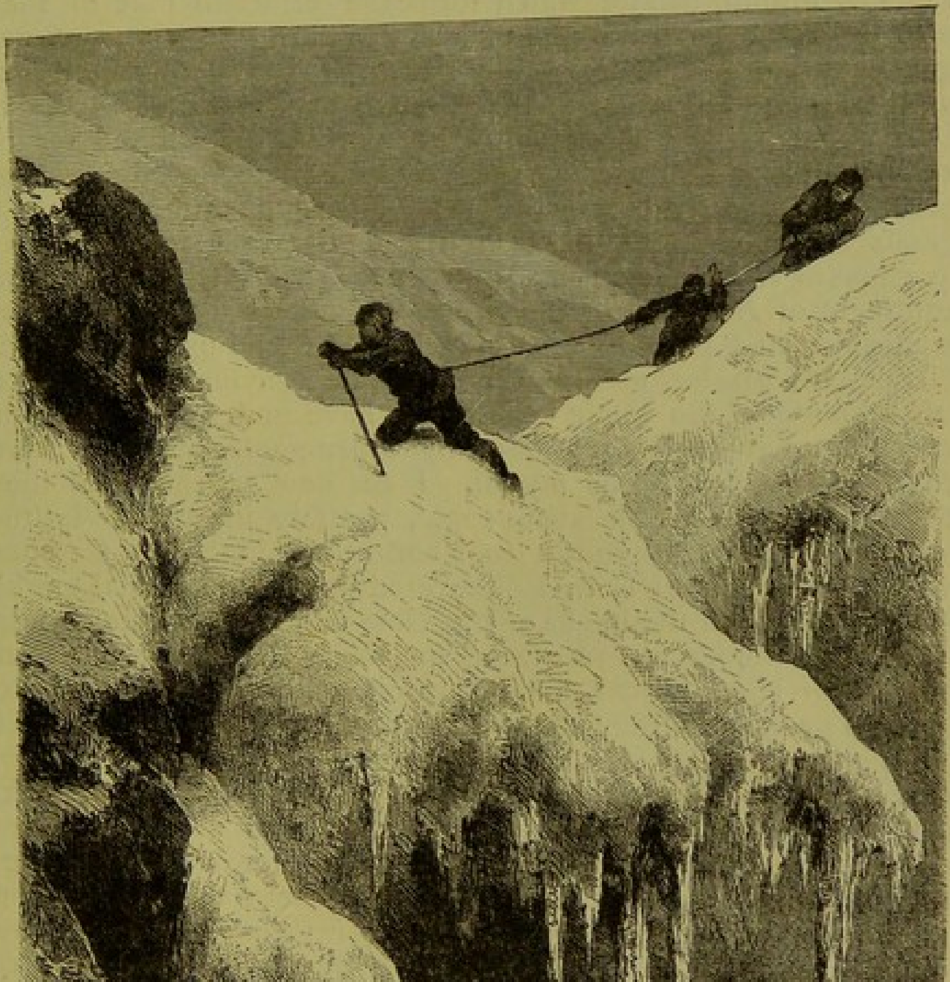
Former Extent of Glaciers—The Glacial Period.

The result of the various investigations carried on in many branches of science connected with our subject has been the placing beyond all reasonable doubt the fact that at one period of the past history of our planet certain parts of the earth's surface were exposed to a much colder climate than that which we find prevailing in the same places at our own time. This so-called glacial period, traces of which are found reaching back to the end of the tertiary age, has been the subject of much study on the part of scientists, who have tried to determine its extent over our present continental and island system, and also to find out the causes which produced the extraordinary and persistent depression of temperature.

As to the former question, new discoveries are being made almost daily. Erratic blocks and moraines, markings, polishings, and groovings of rocks are the chief signs which betray the former presence of glacier ice. To begin with the continent of Europe, it is proved that the whole of Switzerland was covered as by one unbroken glacier, much as Greenland is at the present day; that enormous glaciers slipped and fell from the Vosges, the Pyrenees, and the Scotch mountain chains, while almost at the same time vast icebergs wandered away from Scandinavia, and brought with them those great blocks of stone which are still lying in the valleys of northern Europe. The valley of the Etsch was also covered by immense glaciers, as was also the whole width of the broad valley near Méran. Of the latter, Fuchs writes as follows:—

"The glacier began at the so-called Töll, the narrow pass at the beginning of the central valley of the Etsch; it forced its way between the boundary peak and that of the Roszbichl, which projects from the south side of the valley, passing partly over the latter peak, and so imparting to it its present rounded shape, and marking it with clearly visible grooves. On the other side of the Töll the glacier widens as far as the shape of the valley allows, leaving upon both sides the trace of its movement toward the east from the west by many a deep furrow and polished surface, and leaving behind it immense moraines, which extend above Castle Tyrol to the summit of the Mutt, and along the other side by the Marlingerberg above Castle Forst. Not until it reached the Kuchelberg, which extends for a mile and a half between the valleys of the Etsch and the Passer, was the great glacier checked in its advance, and even then the attempt to arrest it altogether was fruitless. It slipped and glided right over the opposing hill, which is about 850 feet high, rounding, smoothing, and polishing its surface in the most extraordinary manner, and then sinking down into the Passer valley. Having continued its way across this valley, it passed behind the Passeier gate of Méran, and the markings left behind the Zenoburg shew that its course was still held in the same direction. At last, however, the giant walls of the Iffinger and its outlying mountain rose as a barrier which it could not overcome."

Carinthia, especially its central parts, was also covered with glaciers. It is said that at the time of the first glacial formation in Switzerland one single glacier of great extent lay above the whole of central Carinthia, and was at least 2,000 feet thick. The melting of this and other glaciers caused the diluvium which formed the plain of Klagenfurt-Bleiburg. It is not so fertile as the Erraticum, which rises to heights of more than 4,000 feet, and forms the ground of many a high field. It is generally supposed that the terminal moraines of Raibel, in the valleys of the Möll and the Malnitz, correspond to the second Swiss glacial period. The extent of this second period was much more limited than that of the former. At the time of the first ice formations in Carinthia the climate was such as to allow of a rich animal and vegetable life; and it is thought that to explain the vast extent of the



ASCENT OF A GLACIER.

glaciers of Carinthia we need only presuppose a decrease of temperature of 6·8° Fahrenheit.

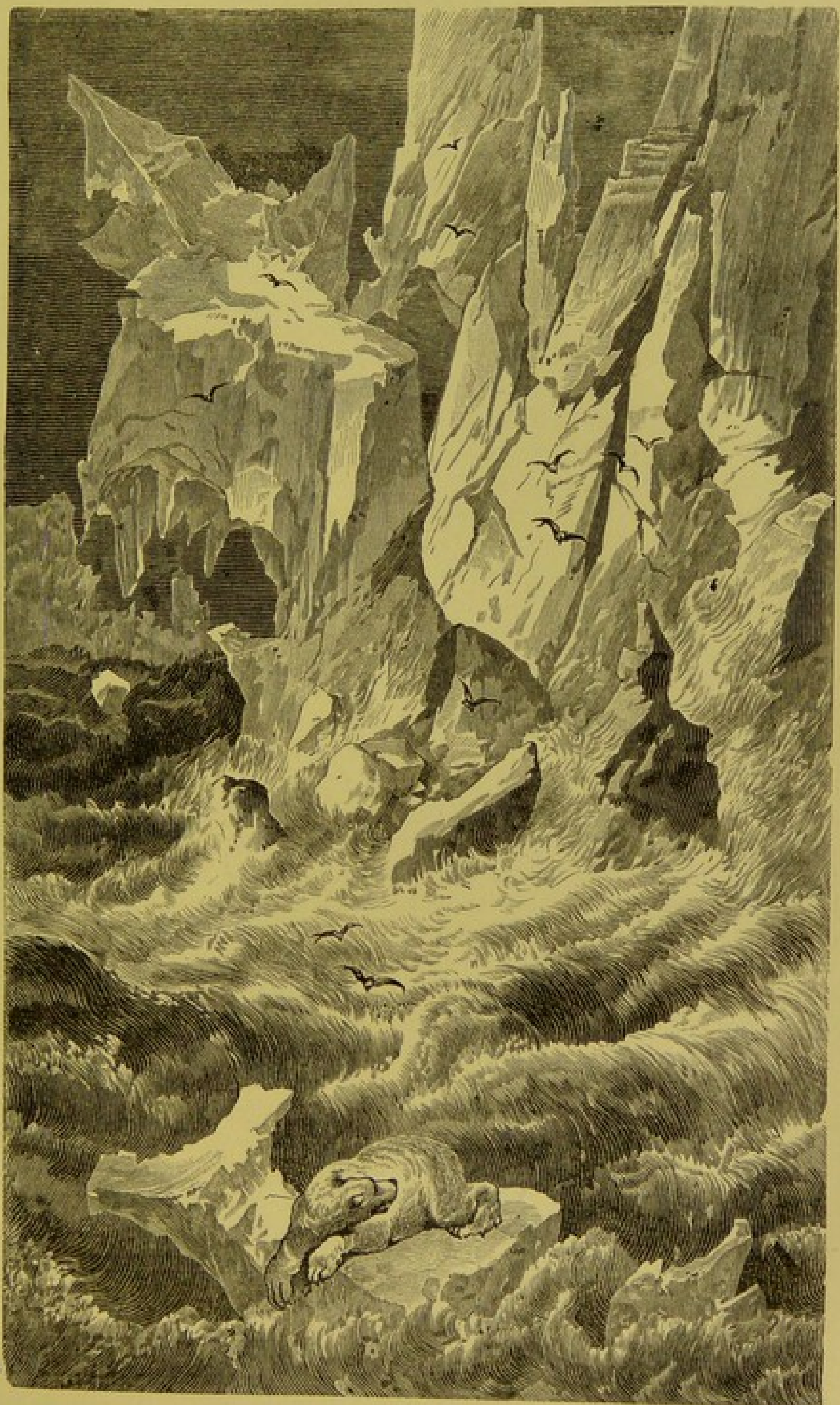
The enormous extent of the glaciers of Switzerland prepares us for the colossal masses of ice piled up upon the Norwegian mountains, and gliding down as glaciers into the valleys, even if they had not left tokens of their presence behind them in the form of the so-called *erratic* blocks. But with respect to the influence exerted by glaciers on the formation of the Norwegian fiords and the depth of the North Sea, we must warn our readers that both statements have been severely criticised by more than one scientific writer, and that at present the weight of evidence is decidedly against them.

Turning from Europe to the continent of North America, we find that here also large glacier fields have left their traces on the rocks of to-day.

In the high regions of the Californian Sierra Nevada, between the 36th and 38th degrees of north latitude, that is, below the most southern point of Europe, glacier markings have been found extending over a space of hundreds of miles. The granite masses which form the principal part of the rocks appear as if furrowed, lined, and planed, and there are many traces of moraines, all lying in the direction of the valley's course. From all appearances the extent of the glacial formation seems to have been greatest on the western slope of the range. If this could be proved, it would furnish another instance to shew that then, as well as now, the supply of meteoric water was greater on the oceanic than on the continental side of the mountain.

Agassiz claims to have discovered still greater glacial effects in the eastern portions of North America. "In the year 1848," he tells us, "I set foot on the continent of America, and upon my very first walk, taken a few hours after the steamer had brought me to Halifax, I found upon all the hills the familiar traces of glacier markings. I became convinced that at certain periods the climate of the whole earth must have undergone great changes. My observations have been continued by other geologists, who have been led to the same conclusions as myself. I am now satisfied that the whole of North America, down to latitude 36°, possibly indeed to latitude 32° north latitude, or in other words, to Charlestown in South Carolina, was once covered by masses of ice. I discovered undoubted glacial markings in Columbia, as well as on the banks of the Ohio and in the western states, and what I have seen forces me to give as my belief that the North American continent down to the latitudes I have spoken of was subjected to a climate cold enough to necessitate the formation of ice fields such as we see in Greenland at the present day."

The proofs of the American glacial period were so convincing to Agassiz, that when he went to Brazil a short time before his death he thought he recognized there also just as evident signs of glacier formation. "I have found everywhere," he says, "on my journey from Rio Janeiro to the neighbourhood of Pernambuco, the same signs of past glaciers; and when I entered the valley of the Amazon, I was able to perceive that it also had been covered by an immense glacier, which had made its way from the Andes to the coasts of the Atlantic. I am convinced that the detritus which forms the present bed of the Amazon was once ground up by ice, and scattered over the plain, just as the clayey *débris* of the Rhine valley came from the mountain slopes of the Alps, and was washed down by the streams of water flowing from the glaciers. The difference is only this, that the valley of the Amazon was wholly covered by the glacier itself. The surface of the rock does not, it is true, shew the polishing so familiar to the geologist in Europe, because the rocks, exposed for so long to the effects of a tropical sun and warm showers of rain, have long since been worn away to a considerable depth. Nevertheless, they possess the general characteristics which are found everywhere where the rounding effects of glacier ice is seen. Moraines, too, are not infrequent. I had already conjectured, even apart from direct proof, by the general nature of the Amazon valley, that it had once been covered by glaciers. I pointed out in a lecture which I gave at Para, before having visited the Sierra, that I should find there traces of earth moraines; and



BREAKING UP OF ICEBERGS.

when I reached the locality a few weeks later, I did find remains which are exactly similar to those found in the neighbourhood of our Alpine range."

The conclusion, then, to which Agassiz arrives is, that in Brazil, in a country upon which the burning sun of the tropics sends down its hottest rays, an ice field formerly extended, reaching from the valley of the Amazon to the Atlantic Ocean, and perhaps covering the surface of the sea to such an extent as to make it a question whether, as we ask of the poles at the present day, there was at one time one drop of liquid water to be found at the equator itself.

These are remarkable conclusions; but the question arises, how far Agassiz's observations may be trusted. Caution almost amounting to suspicion is above all demanded when the scientific enquirer begins his chase after glacier markings. For instance, where in Morocco one geologist found wholly incontestable evidences of a former glacial period of great intensity, others saw only surface scratchings and mounds of *débris* caused by landslips, instead of glacier markings and moraines. Similar objections have been made to the statements put forward by Agassiz. The scientific observers of Santiago see nothing but pure eruptive formations where Agassiz found clearly defined moraines; and as to the valley of the Amazon, the investigations instituted in the year 1872 shew that its former glacial covering is at least highly problematical; and it may well be conjectured that traces of a prehistoric ice period reported in several other tropical regions are open to equal suspicion.

All that we know for a certainty, so far, is that one, or it may be several, periods of intense cold have prevailed in certain latitudes of the temperate zones; and this brings us to the second enquiry, namely, what was the cause of this strange and anomalous phenomenon? There is no lack of hypotheses on the subject, of which we will only mention the most deserving of attention.

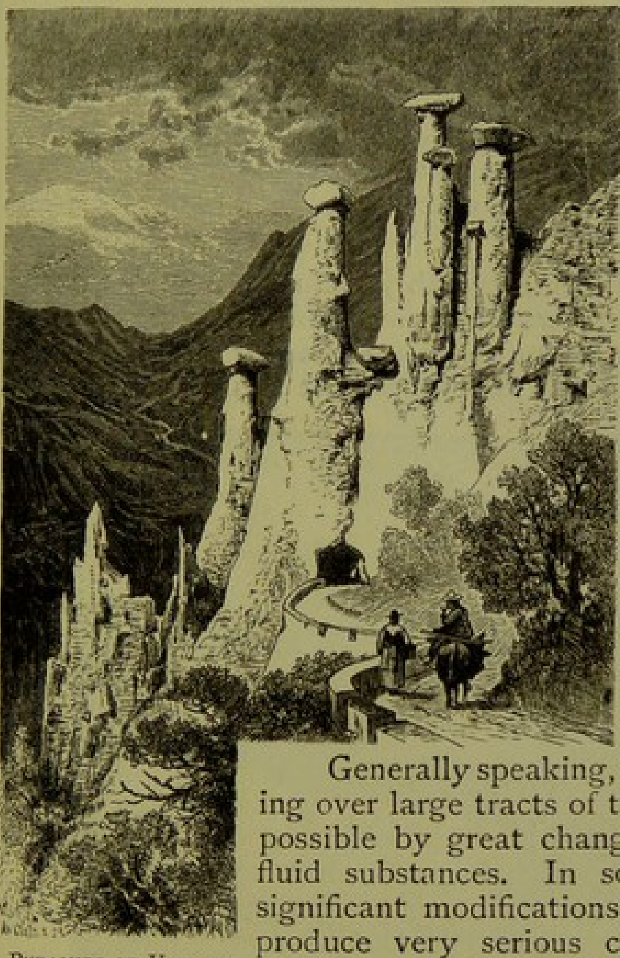
It was at first supposed, and the supposition was the one most likely to present itself first, that in the glacial period the sun gave out less warmth than it does now. If we assume that the radiation of the sun's heat was very unequal at different times, sometimes much greater and sometimes much less, the same hypothesis would be available also to explain the greater heat which once prevailed in the Arctic regions. But from all that we know concerning the origin of the sun and of our earth, we are led to the conclusion that at first the sun gave out more heat, or at any rate no less heat, than it does in the present day. We find, therefore, no reason here for any glacial period, and no explanation of a tropical climate in the Arctic regions during the tertiary period. For even supposing that we assume a sufficient amount of heat to have prevailed during that time to admit, while the sun was above the horizon, the development of magnolias and plantains in Greenland and Spitzbergen, the cooling down during the arctic night must have been enough to reduce the temperature far below freezing point. The sun does not rise for two whole months in latitude 70°, while it is absent for three months in latitude 75°, and four months in latitude 80°. During these various periods the air and the earth are throwing off heat into the cold spaces near them without any interruption, and without receiving any compensation. The result is, as we know, the extremely low temperature of the Arctic regions. This is the true reason, and not the lack of intense heat during the short summer season, which forbids any growth of trees within the latitudes of which we are speaking. The atmospheric temperature in Taimyrland in the beginning of August was 60·8° Fahr., and on the earth it was 75·2° Fahr., or about the same atmospheric temperature which is recorded in central Germany during the summer months. Nevertheless the regions of Taimyr-land are amongst the most desolate and most terrible on the face of the whole earth. As soon as the arctic summer begins, mosses and tiny flowerets appear on the sunny slopes, as if they were hurrying out into blossom, that they might live through their life before winter overtook them. If we imagine the summer temperature of these regions raised to twice its actual height (and this would imply the transformation of large stretches of land in the torrid zones from lands rich in animal and vegetable life to desolate sun-scorched wastes), the sum of heat then received into the air and earth would not be sufficient to preserve the plants from being frozen during the winter. And if the inner heat of the earth were called to the aid of the dying vegetation, and supposed to be nearer to the surface of the earth than it is to-day, it would still be of no avail. For if the inner heat of the earth is to be sufficient to preserve plants from freezing during the long polar night at a height above the ground ranging from twenty to forty feet, the heat close below the surface of the earth would have to be so great that every vegetable germ would be burnt up.

This once favourite theory of the fostering influence of the earth's central heat upon the climate during certain geological periods is wholly untenable. It has been thoroughly tested by the mathematicians Thomson and Fourier, and shewn to be utterly worthless. These writers prove beyond all doubt that even in the earliest geological periods the earth's inner heat exerted no influence whatever upon climate; or at the outside, during the first ten thousand years after the process of cooling began, the surface may have been affected by the heat from within. A higher temperature would be perceptible in the upper strata during the first three or four million years, but at the end of that time the increase of temperature would amount at most to ·1 degree per foot; and during the course of the succeeding ninety-six millions of years would decrease to ·02 degree per foot.

It has been suggested as an answer to the difficulties which are raised by the suggestion of a lesser amount of heat thrown out by the sun, that the earth was once much farther from the sun than it is at the present time. If the earth revolved at the same distance as the planet Mars, it would receive less than half its present amount of heat, and would doubtless, like that planet, be crossed with zones of ice extending to latitude 55°. But it is not probable that the earth was much farther from the sun in the glacial period than it is now. And according to this theory the frozen state of the earth before the tertiary period must have been far greater than we have any reason to believe that it was.

Another view was put forward by Adhémar, to the effect that the phenomena of the glacial period could be explained by the 21,000 years' duration of the rotation of the apsidian line, and the circumstances to which it gave rise, but his opinion was never accepted by trustworthy authorities. More plausible is the revised theory of Schmick, and what Peschel and others say against it is insignificant. Croll endeavours to explain the glacial periods by changes in the eccentricity of the earth during long lapses of time. He deals with spaces of many hundred thousands of years, and removes the last glacial period from the year 240,000 to 80,000 before Christ. But on examination of the remains found from the glacial period, this calculation can by no means be accepted.

Lyell seems to have been the first who sought for the causes of the glacial periods in purely telluric circumstances; namely, in the distribution of solid and liquid matter upon the earth's surface. It was at first thought that this solution arrived at by the famous English geologist was of too local a character to be accepted as the explanation of such great and universal changes of temperature. In time, however, opinion has yielded a general assent to Lyell's theory, especially since the statement put forward by a German writer in 1852, that an inundation of the Sahara in the past tertiary period would easily explain the colossal dimensions which the Alpine glaciers had at that time. A south wind which, in the state of things then existing, reached the Alps laden with moisture, would discharge upon their peaks great masses of snow, so that the wind which now lessens those masses would then considerably increase them.



Pyramids of Useigne.

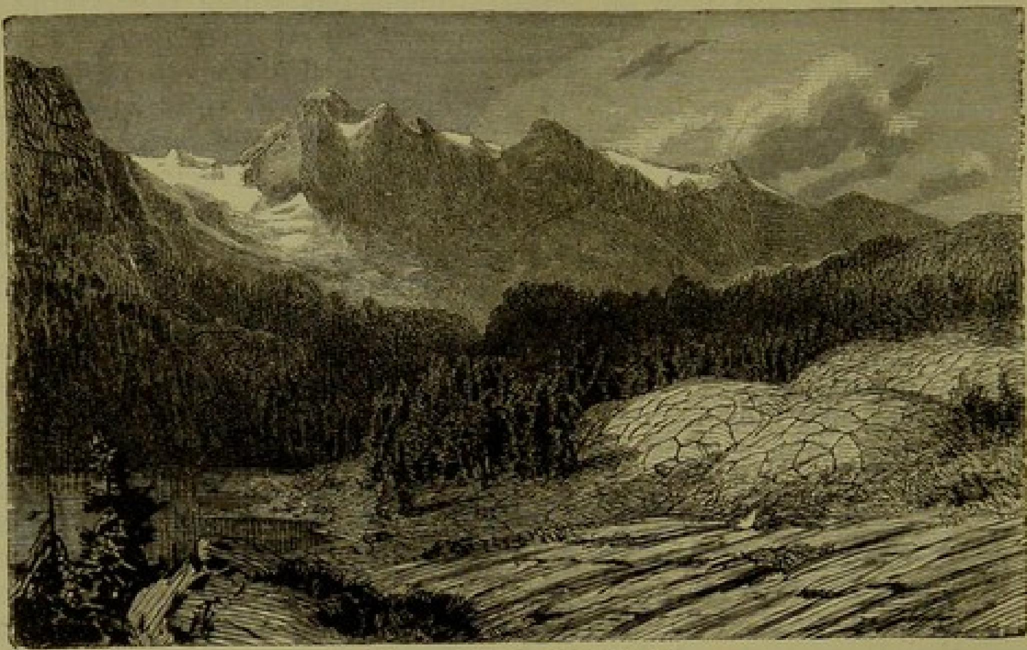
Generally speaking, important climatic changes, extending over large tracts of the earth's surface, are only rendered possible by great changes in the distribution of solid and fluid substances. In some cases, however, relatively insignificant modifications in the configuration of the coasts produce very serious climatic changes. For instance, a deviation of the Gulf Stream from the European coasts would bring about the greatest changes in the climate of western and north-western Europe. The contrasting temperatures created by this warm current between the European and North American coasts will speak for themselves in the following table of comparison, shewing the average monthly temperatures of two stations in Norway and Labrador:—

	Nain, Labrador. N. lat. 57°10′	Bergen. N. lat. 60°24′		Nain, Labrador. N. lat. 57°10′	Bergen. N. lat. 60°24′
January	1° Fah.	34·9° Fah.	August	50·8° Fah.	58·5° Fah.
February	3·5° „	36·7° „	September	447 „	54 „
March	7·5° „	37·2° „	October	33 „	47·8° „
April	30° „	44·2° „	November	26° „	40·8° „
May	36° „	51·3° „	December	6·4° „	37·5° „
June	42·6° „	56·4° „	Greatest		
July	50·2° „	60·2° „	difference	50 degrees	25·3 degrees

To be able to understand from this table of temperatures the real influence of the warm waters of the Gulf Stream, in contrast to the polar arctic currents flowing southward along the coast of Labrador, it is necessary to take into account the corresponding normal temperatures of the parallels of 57° and 60⅓°. Dove has drawn up such a table for the separate parallels, deduced from experiments; but instead of using the table drawn up by him it is better to use the one mathematically calculated by Mach on the supposition that the temperature at the equator during the time of the equinox is as Humboldt gives it, 81·7°. The following table shews the difference between the calculations and the reality :—

	Nain, Labrador.	Bergen.		Nain, Labrador.	Bergen.
January	20·5° Fahrenheit.	5·85° Fahrenheit.	July	4·6° below zero.	8·2°
February	12·6°	49·6°	August	12·6°	22°
March	16·5°	31·9°	September	26·8°	39°
April	11° below zero.	15·4°	October	35·3°	54°
May	12·5°	3·7°	November	43·5°	61·8°
June	15·2°	2·1° below zero.	December	30°	64·5°

We see from this table how very unfavourably Nain is situated in comparison with Bergen ; the real temperature being invariably below the normal one. The higher temperature given in the table for October and November is only apparent, as in the calculations the maximum heat was taken for June,



Glacier Markings in Rocks.

while in reality it falls two months later, just as the hottest time of the day is not noon, but two hours later. And, as is also shewn, the influence of the Gulf Stream makes itself felt at Bergen in the winter months by a great rise in the temperature of the air, while, owing to its geographical position, the summer temperature is proportionately lowered, although it rises in the monthly average for July to 60°. Just the contrary is the case with Nain, where, in consequence of the northern arctic currents, all the average temperatures are lowered in August to 51°, and in January to 1° Fahrenheit. The result of this is obvious. The sun, in and by itself, even if it sent out much greater heat than it actually does, would not be able to produce such a climate as is enjoyed by Bergen in the autumn and winter months, in 60° N. lat., its position in this respect being about the same as that of the Alpine chain. Such average sea-temperatures are only possible where fresh heat is continually being supplied to replace that which in the long polar night is dispersed into the cold spaces around. This necessity upsets all cosmic theories put forward as an explanation of the heat once prevalent in the Arctic regions ; and conversely, if the amount of heat given out by the sun were diminished by one half, the average temperature of Labrador would not thereby be lowered to such a degree as that given in the preceding table. This proves that the sun has nothing to do with the creation of a glacial period such as still exists in Labrador, but that the distribution of solid and fluid, by which the course of the cold ocean currents is determined, must be regarded as the chief cause of the phenomenon. In this we see the principal cause of the glacial period of central Europe; and that which has happened in the past may occur again in the remote future.

Earthquakes.

If the world-old upheavals and depressions may be likened to the long, deep-drawn breathing of our planet, which is utterly removed from direct obser-

Ruins of St. Nicolas's Church in Lisbon after the Earthquake of 1755.

vation, since it changes the surface of the earth after a lapse of centuries, there are sudden convulsions which destroy in a moment our long-established faith in the stability of the solid earth beneath our feet. At the sudden earthquake an unknown force of nature rises mysteriously, as if endued with life and terrible active force. We are disillusioned as to the repose of nature, and carried into the kingdom and placed under the sway of unknown destructive forces. We can no longer trust the very earth on which we tread. The strangeness of the phenomenon awakes the same terror and disquiet in the animals around us. Dogs and pigs are specially seized with fright. The crocodile of Orinoco, generally as dumb as our own little lizard, leaves the shaking bed of the river, and hurries moaning toward the forests. It is the rarity of the phenomenon which most of all affects the minds of men; for in districts where an earthquake is as common as a shower of rain is in our own country, the inhabitants are so thoroughly accustomed to it, that they do not even notice the slighter shocks. In certain parts of the Sunda Islands, and in South America, the doors are left open at night, so as to prevent the inhabitants of the houses from being shut in, in case a more serious catastrophe should displace the walls, and prevent the opening of the doors. In our own country, slight shocks of earthquake are of much more frequent occurrence than is generally supposed. The delicate instruments constructed by D'Abbadie frequently shew slight tremblings of the earth's surface, which cannot be detected by ordinary observation. Great earthquakes, like the terrible catastrophe which wrecked Lisbon in the year 1755, spread their circling waves over whole continents, and even moderate shocks extend to very great distances, although they can only be detected by the aid of instruments. It has been said that if the condition of the earth's surface at one and the same moment could be recorded by trustworthy instruments, it would probably be found that at no moment it would be at complete rest in every part; and we may boldly add to this statement, first made by Humboldt, that the testimony of such instruments would prove that a far greater part of the earth's surface would be found in movement than in rest. This assertion seems probable on the face of things, when we remember that there are such numerous causes always at work to disturb the motionless rest of the earth beneath our feet. D'Abbadie has shewn by his instruments that every shock of the waves against a coast disturbs the shore perceptibly to a distance of several hundred yards inland. When, in the years 1772 and 1810, fragments of rock fell from Shakespeare's cliff into the sea, a very perceptible shock was felt in the earth at Dover. In Essex, every stroke of Krupp's great hammer shakes the ground for a considerable distance around; and the same shaking is noticed during the passage of heavy goods trains. The explosion of gunpowder which did so much damage in Mayence in November, 1857, caused a vibration of the earth which extended from Cassel in the north to Carlsruhe in the south. In Argyleshire, when a block of granite 75,000 tons in weight was sprung by four tons of gunpowder at one blast, no report was heard, but the whole earth seemed to quiver to its foundations when the great mass began to be dislodged. On the 12th of November, 1869, a superficial shock was felt near Zella, a chasm twelve feet wide, fourteen feet long, and fifteen feet deep, opening in the earth, and causing such a vibration through the surrounding neighbourhood, that chimneys fell in, and a slightly built house was so dangerously shaken that it had to be propped up. In Ronsdorf, in Rhenish Prussia, an earthquake lasting for several hours occurred on the 16th of January, 1875. Its effects were limited to an area of from 120 to 180 square yards, and made great havoc in the adjoining stone quarries and woods. The shock was first observed by some workmen on their way to their daily work. They noticed a swaying movement, and saw some heavy pieces of stone, laid ready for use by the builders, removed from their place to a distance of two or three yards; while rifts of three yards in width opened in the earth. A workman in a shed was lifted from the ground, together with the shed itself, and with loud cracks stones, buildings, clay, and masses of black earth fell into the openings, and the men had hardly time to make good their retreat.

The movement of an earthquake is either vertically upward or undulating, and as a rule in a straight line. The vertical shocks, unless very severe, generally make themselves felt by the clinking of glass and rattling of china in dwelling houses; severe shocks cause beams to crack and chimneys to fall, and set bells ringing, while the most violent tear down walls, and convert the strongest buildings into a heap of ruins. In the terrible earthquake of 1783, which desolated Calabria and Sicily, and cost the lives of more than 100,000 men, the first six shocks were so violent that the mountains broke from their foundations, and part of one eminence near Scylla was dashed into the sea. More than 100 hills were overturned, and more than 400 towns and villages were completely annihilated by this earthquake. As an instance of the force of a severe vertical shock, it may be stated that a man and his wife were raised, with the ass on which they were riding, and the ground under their feet, and thrown across a river; a citron tree, to which a man was clinging, was dashed to a considerable distance, with the earth in which it was growing. In the earthquake which happened at Catanea in 1818, several walls were torn asunder for a moment, so that the moon was visible through the cracks, and then violently closed again. The existence of rotatory shocks is rightly doubted, although certain phenomena apparently speak for their occurrence. Thus, after the earthquake at Catanea, several statues were found turned round, and after a severe shock at Valparaiso, on the 19th of November, 1822, houses were found turned, and palm trees twisted together like willows. At the great earthquake of Riobamba, in the province of Quito, on the 4th of February, 1797, masonry was turned round without being overthrown, and straight lines of plantations appeared curved and bent; while fields sown with different kinds of grain were mixed together. When Humboldt traced the ground plan of the ruined city of Riobamba, he was shewn one place where all the furniture of one house lay buried beneath the ruins of another. The lesser tracts of earth had been set in motion like a fluid substance. Isolated articles were carried to distances of more than 1,000 feet, and many disputes as to the ownership of property recovered from the ruins were brought before the courts of law. Sometimes funnel-shaped openings of the earth are noticed in earthquakes, probably caused by the falling in of the ceilings of subterranean caverns. In other cases the earth opens, and everything standing upon it falls into bottomless depths below. The delta of the Indus was visited by a terrible earthquake in July, 1819. A surface of 1,500 square miles fell in, and was covered by the sea. The garrison of Fort Sindree escaped with the fright, for the fortress remained uninjured, and the men were saved by boats next day. At the same moment the ground rose about ten feet over a surface of more than eight miles, forming a mound which the natives call by the name of Allah-Bund, or God's Dike. In the year 1834, a tract of forest land more than three square miles in extent, near Chili, not far from the city of Santiago, was swallowed up in the earth which buried the crests of its tallest trees; and near Chittagong, in Bengal, in 1762, the earth swallowed up several mountains, not leaving the highest crest visible above the surface. The hollows are generally filled up by water, and many a legend of buried cities lying beneath the surfaces of quiet lakes is doubtless due to some long forgotten earthquake.

The speed at which the earth wave is developed along the surface is very difficult to determine; for all those who are on the scene of an earthquake have little time or inclination to make delicate calculations as to the minute of time at which the shocks travel. Humboldt imagines the rate of speed to be about twenty-two to thirty miles per minute.

The earthquake of the 15th of January, 1858, which extended over an area of 22,800 square miles, affecting Bohemia, Silesia, Schleswig, and Moravia, the neighbourhood of Sillein, in north-western Hungary, being the central point, was thought by Schmidt to possess a rate of speed of six miles per minute. The earthquake in the Rhine provinces, 29th of June, 1846, moved at the rate of nearly sixteen miles a minute. There is no doubt that the speed of the earthquake wave varies according to the nature of the ground through which it passes. It has been observed by Mallet, that in firing mines the speed has been 251 yards a second through loose sand, 398 through granite, and 507 through very hard granite masses. Abbot has availed himself of the springing of mines carried on in the school for submarine mining at Willet's Point, to study the speed at which the shock travelled. He found that the development was quicker in proportion to the violence of the first shock, and diminished in speed as the wave of vibration extended farther from the original impulsion. The movements of the earth's crust are, he says, extremely complicated, consisting of many short waves, which first increase and then diminish in extent. The speed of the whole wave, as it advances, must be distinguished from that of the separate particles of each wave; the latter is of course much less, and only amounts to between three and five yards on an average. The formation of the earth is of great importance to the intensity of the shock. It was well known to the ancients, that the shock is much slighter above subterranean caverns and hollow spaces, and Vivenzio is of opinion that the Romans sank several wells beneath the Capitol with a view to protecting it against earthquakes. The good effects of underground cavities have been noticed also in times of earthquake by the inhabitants of St. Domingo. In other places it has been observed that pauses occur at regular intervals in the vibratory wave; the surface remaining undisturbed, and the oscillation continuing underground. The Peruvians say of these immovable upper surfaces, that they form a "bridge." It is a circumstance of frequent occurrence, that in districts where earthquakes often happen, the circle affected by them widens in time, as if some underground obstacles had been overcome, and the disturbance proceeded along a more uninterrupted course. Mountain chains often act as protecting forces, which bar the passage of the advancing earthquake wave, and turn it aside, so that the circle of disturbance is changed into a zone. In stratified rocks the wave advances parallel to the strata. Whether loose porous earth is specially dangerous in an earthquake must remain for the present an open question, as there are instances for and against its being so.

The slightest and least dangerous earthquakes are either over with one shock, or are followed by tremblings of the earth at long intervals. In very violent earthquakes the shocks succeed each other very quickly, the first being generally the most severe. In the earthquake which destroyed the Caraccas, on the 26th of March, 1812, there came first, as if it were a warning signal, a sudden shock which set the bells ringing. The people hastened into the churches, which, however, were changed into heaps of ruins by the next shock. A regiment of soldiers, who were standing under arms in the barracks of El Quartel, having been drawn up ready to start in procession as a guard of honour for the celebrations of Maunday Thursday, disappeared every one under the ruins of the barracks. Nine-tenths of the town was destroyed, and the rest rendered uninhabitable. Ten thousand people lost their lives in an instant, besides the great number who came to a slower and more terrible end by mutilation and hunger.

The general opinion that all danger ceases after the first violent shock does not meet with confirmation in fact. On the contrary, the convulsions which destroyed Messina, and did such damage in Calabria, recurred with pauses of varying duration from the 5th of February to the 28th of March, 1783. The famous earthquake which devastated Switzerland was ushered in by a shock felt in Bex on the 19th of July, 1855, and lasted with interruptions till the 18th of December, 1856.

The areas of disturbance of separate earthquakes are very various in extent. If the extreme points at which the shock of the same earthquake is felt are joined on the map by a line drawn from one to another, the line will often be found of an elliptical form. Besides these central earthquakes, with their elliptical direction of concussion, there are linear or horizontal earthquakes with a zone instead of a circle of concussion. The latter kind is more frequent in countries where there are important mountain chains.

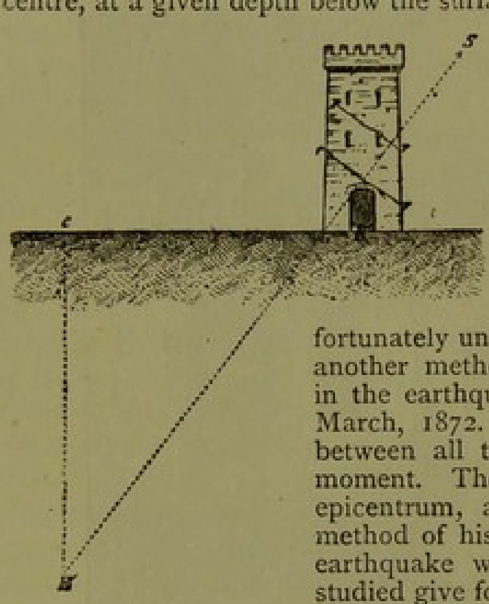
The terrible earthquake of Lisbon, which we have previously mentioned, was felt more or less in Greenland, Canada, the Antilles, North Africa, Spain, France, Switzerland, Germany, Sweden, Norway, and Iceland. The earthquake in South America, August 1868, extended its destructive influence from north to south, over fourteen degrees of latitude, or about 945 statute

THE DESTRUCTION OF AREQUIPA IN THE EARTHQUAKE OF 1868.

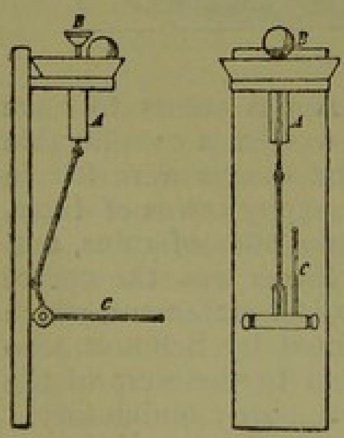
miles. On the eastern side, the high chain of the Andes seems to have formed the boundary of its advance, whereas on the western a considerable part of the bed of the ocean was affected by it. The shocks were felt in their greatest intensity in the neighbourhood of the unhappy towns of Islay, Arequipa, Arica, and Iquique, which were changed into piles of ruins, and there is no doubt that a district occupied by those towns was the centre of the disturbance and true focus of the shocks. This last statement, which is given on the authority of Van Hochstetter, is refuted by Schmidt, who places the centre of disturbance in the bed of the ocean to the west of the South American coast. The shocks were partly vertical, partly undulatory.

It is very often a matter of great difficulty to determine the direction from which the horizontal shocks proceed. The evidence of those present generally is contradictory, which need not surprise us when we consider the state of fear and surprise in which every one is placed by the sudden terror of an earthquake. Generally the kind of damage done, and the direction in which various articles are displaced, furnish the best evidence as to the course of the shocks; but even then observations have to be made with great caution, as is shewn by the investigations made in the earthquake of Clana, in the Karst district, on the 1st of March, 1870. It was then found that the direction of the fissures in the walls was no guide whatever as to the direction of the shocks. From the displacement of several objects, especially statues, the direction was found to be first from the north-west toward the south-east, and secondly from the south-west toward the north-east.

Careful investigations as to the depth and position of the earthquake centre were instituted by Mallet in the great earthquake of Calabria, 16th of December, 1857. He found, by the direction in which certain buildings had fallen, the centre on the earth's surface, or so-called epicentrum; and it is clear that this surface centre must lie near the intersecting points of lines produced from the directions in which the buildings fell, and that vertical to this centre, at a given depth below the surface, would be the real focus of disturbance. Let *c* be



the surface centre, and H the real centre in the interior of the earth, from which a shock is sent out in the direction H S. Let the shock come in contact with the building K, and rifts will be formed in the walls, of which the general direction shall be vertical to the direction of the shock. If, then, the distance of the building from the surface centre is known, it will be easy to calculate or construct the real centre H, and its distance below C. Mallet's method, as shewn here, is only adapted for places in which earthquakes occur on a large scale, and is fortunately unsuited for those of our own country. For the latter, another method has been invented by Van Seebach, and applied in the earthquake which occurred in the centre of Germany in March, 1872. The epicentrum was found by drawing a line between all the places in which the shock was felt at the same moment. The central point of this circular line shewed the epicentrum, and v. Seebach then proceeded to calculate by a method of his own the depth of the focus and the speed of the earthquake wave. The earthquakes which have been already studied give for the real focus depths varying from 10,936 to 43,744 yards, shewing that the destructive force is seated very near the surface of the earth. Important results may be hoped for when the times of the shocks at the different places affected are more accurately taken. And in order to procure the greatest



possible exactitude, several instruments have been used, the simplest of which is the seismometer invented by De Lassaulx. The accompanying figures give a front and side view of this instrument. In a little case, A, is a spring, which, in connection with a slender bar of steel, weighs down the handle of a lever *c* attached to a thin wooden board on a revolving axis, by forcing upward the steel bar, whose upper end is in contact with a small brass plate B. On this plate rests a brass ball, which moves the spring in A, and causes the lever *c* to fall back against the board of wood to which the whole apparatus is screwed, as shewn in fig. 2. Round the ball and the upper opening of the case holding the spring is a round wooden dish, to catch the ball when it falls from the plate. In this dish are eight compartments, into one of which the ball must necessarily fall, thus marking the direction in which it has been thrown. The apparatus is used in the following manner: It is fixed near the pendulum of a clock, so that the pendulum can vibrate in front of the lever *c*, which is lying close to the clock case, the brass ball being in position above the case. As soon as a shock takes place, the ball is thrown down, the spring starts up, and causes the lever to fall in front of the pendulum, thus stopping the clock instantly. The compartment into which the ball has fallen shews the direction in which it has been thrown, and the clock gives the exact time of the shock.

The tremulous motion of the earth is frequently accompanied by subterranean noises; sometimes the noise is heard after the shock, and sometimes it is altogether absent. No sound was heard accompanying the fatal shock which laid the city of Riobamba in ruins. The terrific thunder which rolled underground below the towns of Quito and Ibarra was not heard till eighteen or twenty minutes after the real catastrophe. Sometimes, indeed, there are subterranean detonations unaccompanied by any movement of the earth's surface. Thus, long after the earthquake in New Granada, (16th of November, 1827,) the underground thunder was heard along the whole Cauca valley in South America, at intervals of thirty seconds, with great regularity, no disturbance of the earth's surface being perceptible. These voices from below, when not accompanied by any perceptible shock, make a peculiarly deep impression upon all who hear them, no matter how familiar they may be with the phenomenon. The listeners wait with anxious foreboding for what is to follow the subterranean volley. The most striking and wonderful example of intermittent detonations, with total absence of movement, was noticed in the high plateau of Mexico, and is known by the inhabitants under the names of the "roaring" and "underground thunder of Guanaxuato." The sounds lasted for more than a month, having begun in the midnight of the 9th of January, 1784. It seemed from the 13th to the 16th of January as if heavy thunder clouds lay piled up beneath the feet of the inhabitants, discharging alternately long rolling volleys and sharp rattling crashes. The sounds died away gradually as they had come, and were restricted to a relatively small space; for a few miles away, in a basaltic region, they were not heard at all. Almost all the inhabitants forsook the town, in which were stored a large quantity of solid silver bars; after awhile the more courageous returned to fight for the treasure with the robber bands who had taken possession of the booty.

In the terrible earthquake which devastated the town of Oaxata, on the 11th of May, 1870, and extended its effects to other places in Mexico, the underground thunder was so violent that it could only be compared to the simultaneous discharge of more than a hundred cannons, lasting so long and so persistently, that while the houses were seen falling on all sides in the light of the moon, all sound of their fall was lost in the prolonged thunder roll.

During the long period of time in which the earthquakes at Gross Gerau were repeated, a dull roll was often heard underground, unaccompanied by any perceptible shock. At about four o'clock on the morning of the 15th of November, 1869, a rattling clatter, as if wood were being thrown down from a cart, was heard between Darmstadt and Frankfort, together with a dull thumping sound. In a few minutes this was followed by a clinking, as if of glass falling among stones, which so increased in intensity as to be taken for loose chains dragged by a galloping horse over a rough pavement. There was no breath of wind at the time. The clinking seemed to come from the south, and the first noise from the south-west. About nineteen minutes later a roll as of distant thunder was heard coming from west to east, and lasting for about four to six seconds. Not the slightest shock was perceptible during the whole time.

Side by side with all this ruin and desolation, a new terror is added to the effects of an earthquake for the dwellers in sea-coast towns. The shocks communicate their vibrations to the watery masses of the ocean, whose waves rise to a height, and rush forward at a speed, unattained by them in the most violent storms. The cry, "The sea is going back," is the most terrible that can be heard by the inhabitant of the western coast of South America during an earthquake; for he knows only too well that the sea will return in a few moments, and rise far above its ordinary limits, and then woe to everything living or lifeless which lies within its reach. In the high seas the earthquake wave is as little felt as the tidal wave on its way round the globe, following the influence of the moon. Vertical shocks, however, are frequently felt by ships as a sudden thrill, which causes all on board to fancy for a moment that the vessel had sprung a leak. Submarine earthquakes are most frequent in that part of the Atlantic which lies between 7° north latitude and 3½° south, and between 16° and 29½° west long. (Greenwich).

In the great earthquake which destroyed the town of Conçepcion in South America, on the 20th of February, 1835, Darwin, who was then in Valdivia, heard that the seaport Talcahuano was completely ruined, and that a monster wave from the Pacific Ocean had washed away the wreck of the unhappy town. He tells us, "We soon saw proofs of it, the whole coast being strewn with wood and articles of furniture, as if a thousand ships had been wrecked upon it. Several roofs had been washed away from the houses unbroken. The warehouses of Talcahuano had been broken open, and large sacks of cotton, yerba, and other goods were lying about on the shore. Fragments of rock shewed by the marine creatures clinging to them that they must have been hurled upward from very deep water. The base of the island was split open in many places, shewing rifts of an ell in width. The appearance of Conçepcion and Talcahuano was horrifying. The ruins were so mingled together, and the towns had so little the aspect of ever having been a habitable district, that it was barely possible to recall the memory of their former state. In Conçepcion, each house or row of houses stood apart like an isolated heap of ruins; but in Talcahuano, over which the wave had passed, nothing was seen but a confused heap of stones, bricks, and wooden beams. The wave in the bay looked only like a great swelling of water; but wherever it met with any resistance it curled right over, tearing down houses and trees as it rolled onward."

The earthquake wave appeared also in the great earthquake of 1868. An inhabitant of Iquique, after mentioning the shock and a slow swelling of the sea, goes on to say, "I now saw with fresh terror the sea begin to retreat, not slowly as it had risen, but with frightful rapidity, the shore rising higher and higher before me, so that I could see nothing of the water toward the island, and some have told me since that it was all dry as far as the island itself. Then, at a little distance behind the island, there appeared suddenly a long high wave advancing with great regularity toward the shore. There seemed now no time to be lost. I called to my two friends in the house, and pointed out the approaching danger. They came out, but thought that the wave would break against the island. We waited to see if it would do so, and had the grand sight of watching the sea come right over the island at a single bound, the spray seeming to reach the sky. This was our last chance of escape. Amid the increasing roar and dash of the incoming sea, and just as the wave was nearer the mainland than the island, we began to run to the heights. It was almost too late for the last of us, who was standing about ten paces off; for the water caught him and dashed him on among the ruins of the houses, which were falling about us right and left; and as he scrambled up, much hurt by the falling timber, he was again seized and dashed forward. He managed at last to be left on dry land, without knowing how, when the sea had recovered its equilibrium.

"I thought for a long time that I was the only one of the three who had any sufficient idea of the danger, when I told the others to shut the doors and make for the hills, and yet I had not run far before I stood still, and turned round to see what was going on behind me. I certainly should not have done so if I had had the slightest idea of the force of the wave; but as it was I turned in the moment when it touched the land, and the sight which it presented is as clear before my eyes as if I saw it now. The wave, black as night with the sand and dirt which it had scraped up, stood about thirty feet high; it reached up to the balcony of the house, the water and foam pouring above the house itself. If I had even for a moment entertained the hope that the houses would resist the assault of the waters, I was quickly undeceived. In one moment the whole street of La Pantilla had disappeared, with the most terrific crash of the falling buildings; and so far from checking the violence of the sea, the fall only added mountains of wood and wreck to the advancing wave, which tore down the next blocks of buildings with the same rapidity, until the continued rise of the ground robbed it of its height, and consequently of its strength. I ran as fast as I could; and when with much difficulty I had run two hundred paces, I saw the sea advancing on the left, having washed the whole shore by the Pantilla perfectly bare, and rolling before it the ruins of the numerous houses and buildings it had destroyed. At this sight I lost heart and strength. With the sea at my heels, and overtaken by it at the side, I gave myself up for lost, and stood still. But looking back, I found that, after having reached two paces from the spot where I stood, it left me undisturbed, and had sunk back to its ordinary level, and returned to the ocean bed."

A part of the town of Lisbon was washed away by an earthquake wave, when that unhappy town was destroyed in 1775; and the ocean billows rose roaring far above their usual level along the coasts of Spain, England, and Sweden, and of the islands of the Antilles, Barbadoes, and Martinique. In the earthquake of Lima, 1586, the sea rose eighty-four feet in the harbour of Callao. When Syracuse was devastated by an earthquake in the year 1693, the sea retreated so suddenly that many fishes were left on dry land; but the wave soon returned, and with such violence, that it penetrated into the town and fortress, leaving again many fishes behind it as it retreated.

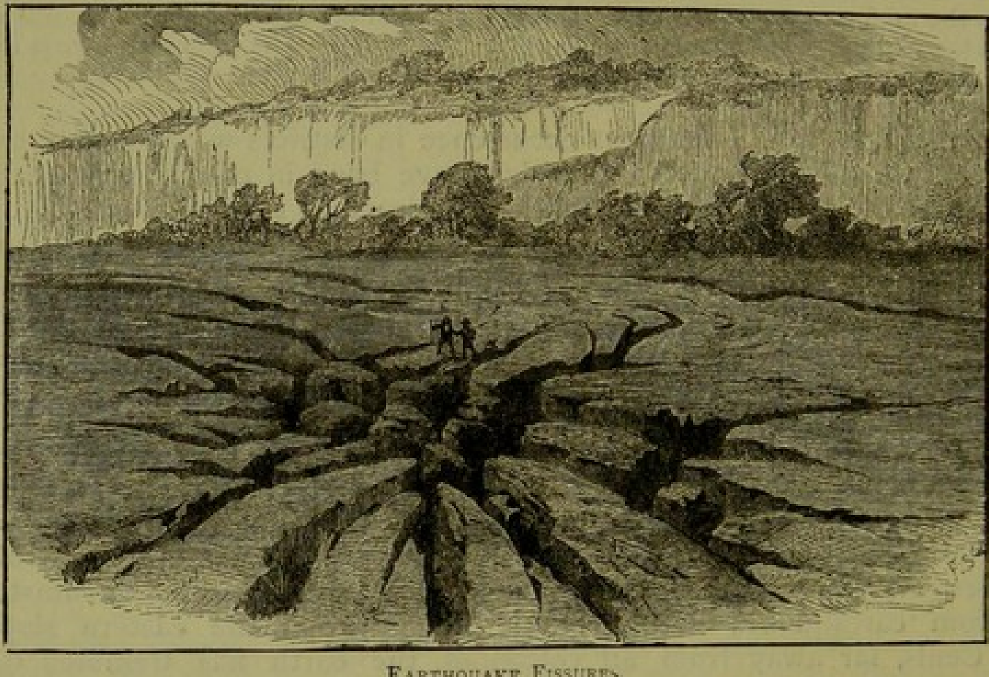
The development of speed in the oceanic earthquake wave furnished a test by which to calculate the average depth of the ocean over which it advanced. The directions for this simple calculation were laid down by Airy, and they have corresponded with the results of the deep-sea measurements. The earthquake wave advances over the ocean with the same speed as the tidal wave, as had been proved by Geinitz in his observations on the wave which followed the earthquake of Iquique on the 9th of May, 1877. The principal wave is followed by secondary ones, which take from two to three days in their gradual extinction.

Earthquakes are of frequent occurrence in districts which either possess volcanoes in a state of activity, or which have been in past ages the scene of volcanic action, as for example South America and the south of Italy. But it must not be supposed that the most volcanic regions are the most frequently visited by earthquakes. The singularly volcanic island of Hawaii, *e.g.*, is relatively free from these catastrophes; and although the natives are familiar with the grand sight of a volcanic eruption, they never knew an earthquake upon their island until the month of March, 1868, nor indeed was there any tradition that Hawaii had ever been visited by such a disaster. The Rhine provinces also are untouched by earthquakes, although they comprise one of the most famous centres of volcanic action in former ages, namely, the district of the Eifel. It can then only be generally stated that volcanic regions are rather more liable to the occurrence of earthquakes than are non-volcanic countries, although the latter are not exempt, under certain circumstances, even from earthquakes of long continuance. Upon the eastern slopes of Mont Cenis, far away from all volcanoes, the earth has trembled during several months, almost every hour of the day and night, since April, 1808.

The question as to whether the dreaded outbreak of an earthquake is heralded by any atmospheric signs which may serve as a warning of the coming shock has been frequently discussed. In darker times, when comets were looked upon as the harbingers of wars and pestilences, fire-balls and shooting stars were supposed to foretell earthquakes and volcanic eruptions. Pausanias held that a long-continued drought was a sign of a coming earthquake, and it is said that in Portugal an earthquake is still expected to accompany the first rain after a drought; an opinion also shared by Pliny, who says that earthquakes often happen when rain falls after violent heat. The erroneousness of the belief that earthquakes stand in any sort of connection with local atmospheric circumstances hardly needs refuting; one has only to reflect that many earthquakes extend over very large portions of the globe, and necessarily affect places of the most opposite atmospheric conditions.

It has been often noticed that, shortly before severe earthquakes, great changes take place in the level of springs and wells. The level falls rapidly, so that the draw-chain has to be lengthened. This happens very often in Naples, and is looked upon as the sure sign of an approaching earthquake. But it should not be forgotten that the surface of wells and rivers is also lowered by long drought.

At times earthquakes are directly connected with volcanic eruptions. A column of smoke, which had been seen rising for months from the volcano of Pasto in South America, suddenly disappeared on the 4th of February, 1797, when the great earthquake of Riobamba happened in Quito, about 216 miles to the south. Strabo records that after a long trembling of the earth through all Syria, the Cyclades, and Eubœa, the disturbance suddenly ceased when in the plain of Chalcis a stream of burning lava poured forth from a fissure. Akin to this statement is the fact that during the action of an earthquake the neighbouring volcano gives signs of life, as was the case in Valparaiso in the year 1622, when the whole neighbourhood was lighted up by the fires of



EARTHQUAKE FISSURES.

the adjoining volcano; and during the earthquake of Lisbon, flames and smoke were seen issuing from a newly opened chasm in the rock of Alvidras, the smoke being denser as the underground rumblings grew louder.

If we turn to the reasons put forward to account for these phenomena, we find ourselves met by the most diametrically opposite explanations. It is only within our own day that anything like an agreement on the subject has been arrived at, or any trustworthy scientific data have been brought forward in support of the explanation offered.

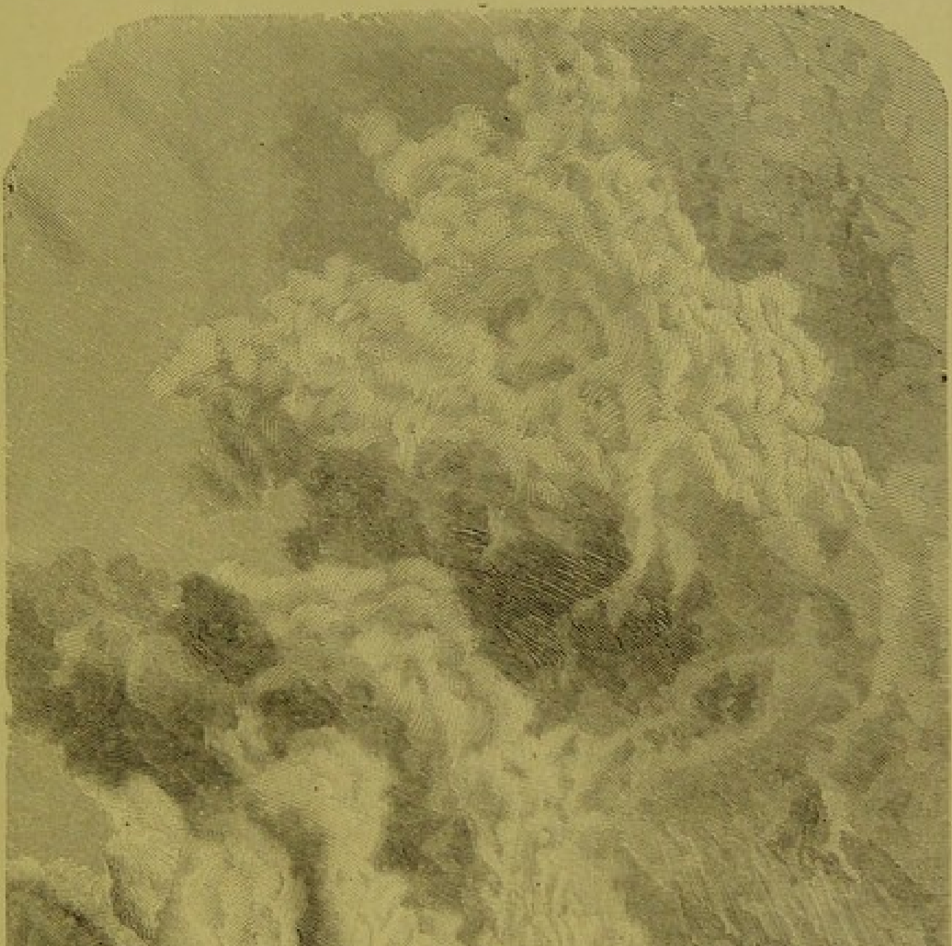
The theories handed down to us by the ancients are all based on the old notion of subterranean storm and disturbances. Aristotle says that the quaking of the earth does not cease until that wind which has caused the disturbance has broken through the earth's crust. So has it happened lately in Heraklea in Pontus, and in times gone by in the Æolian island of Hiera. Ovid describes the process of the earthquake, with its uplifting of the ground, very graphically. He says: "A rugged treeless ridge of earth is seen at Trözene. Once it was a plain, now it is a mountain; for the vapours shut up in gloomy caverns seek for an outlet through a cleft. Then by their power the expanding earth swells like a bubble filled with air, like the skin of the two-horned goat. The raised mound remains, and hardens in the course of time to a bare mass of rock." The clouds of vapour rising from the volcanoes of South Italy early led to the belief in mighty subterranean fires; and the ideas of Hades and Tartarus of the ancient Greeks were probably suggested by the Italian fire-mountains. The ancients believed that the giant Enkalas lay bound in Etna, and that as often as he moved all Sicily trembled; and Dio Cassius tells us that Cyclops rising with a blast of trumpets from the crater of Vesuvius, buried the doomed cities of Herculaneum and Pompeii. The Talmudists, on the other hand, believed that God shed two tears every day in repentance for the dispersion of the Jews, and that the tears, falling into the sea, brought forth earthquakes from time to time. In the middle ages, much was written about layers of coal, sulphur, and saltpetre, which became ignited and broke out in terrible explosions. Soon afterwards, when electricity was better understood, it was held responsible for the disturbances by means of violent lightning-like shocks fulminated in the cloud region. Then came the opinion that the catastrophe was caused by the conflagration of coal underground; and at length a deeper and truer view prevailed. "It is elastic fluid substances," says Humboldt, "which cause not only the gentle, innocuous trembling of the earth, that lasts for days together, but also the terrific explosions attended by loud crashes and rumblings. The seat of the disturbance, and home of the motive force, is situated deep below the crust of the earth; *how* deep we know as little as we know the chemical nature of the highly expanded vapour. I have periodically and very regularly felt earthquake shocks on the edges of two craters, that of Vesuvius and the turret-like rock which towers above the immense chasm of the Pichincha, near Quito; on each occasion, twenty or thirty seconds before burning scoriæ or steam was sent out. The shock was always greater in proportion to the length of time before the outbreak, and the longer the accumulation of gases and vapour remains to gather force. This simple explanation is, roughly speaking, the true solution of the difficulty; and it is confirmed by the direct observation of many travellers." For a long time the theory thus laid down by Humboldt met with cordial approval from almost all geologists; connecting as it did, closely but naturally, volcano and earthquake; and giving as the source of the highly condensed vapours the central heat of the earth. One by one, however, objections began to be raised against the "volcanic theory," and Necker brought forward the opinion that many local earthquakes occur through the falling in of subterranean cavities, occasioned by erosion or the solution of rock salt, gypsum, and other substances. To the objection that the great area over which earthquakes extend was incompatible with such a theory, it was answered that there was no reason whatever for thinking that the falling in of underground recesses did not also affect a very wide area; and indeed an unprejudiced mind cannot deny that as a matter of fact earthquakes may occur, and often have occurred, by such fallings in of subterranean caverns as Necker and Valger suppose.

The idea that earthquakes were occasioned by the action of expanded vapour was widely spread in Constantinople in the sixth century, as is shewn by the following passage of an obscure Byzantine writer :—

"When, in the year 557 after Christ, Constantinople was for the second time visited by terrible earthquakes, the question of their origin and cause was naturally often discussed. Some people believed in the opinion of Aristotle. Others would not for an instant admit that the disturbances could arise from steam and gas enclosed in the interior of the earth. The former reminded their opponents of a curious experiment made by a deceased mathematician, named Anthemios. This man used to make instruments for exemplifying mathematical theses. He was born in Tralles, but had removed from that place to Constantinople, where he lived in the next house to the orator Zeno. The houses, as it seemed, were built under one roof; that of Anthemios being small, while Zeno's was larger and splendid. The neighbours, as too often happens, fell into some dispute, in which the mathematician was worsted by the ready tongue of his adversary. Anthemios went home to plan his revenge. He waited until a day on which Zeno was entertaining a number of friends, and then he set in motion an artificial earthquake, with such success that the whole company, seized with terror, rushed out into the streets with shrieks and curses. For Anthemios had been for many days previous secretly preparing his plan. He had placed in several parts of his house large vessels filled with water, the upper parts being closed with leathern tubes, wide where they fitted on to the vessel, and narrowing gradually toward the top, where they were hermetically closed with a cap of leather. These tubes were directed against the walls of Zeno's house, and carefully fastened close under the roof. A fire was then lighted under each vessel, and the water, soon boiling furiously, sent the steam up the leathern tubes, and violently shook the whole fabric of the houses. Certain that an earthquake had occurred, Zeno hastened to the palace, to enquire about the safety of his friends. When he was met by general laughter and mockery, he did not know what to make of it, since he and his friends had certainly felt the shocks in which no one else would believe."—*Agathiae Hist.* v. 7, *in Corp. Script. Hist. Byzant.*

Much light has been thrown upon the sources to which earthquakes and volcanoes are due, by the careful statistics made as to the frequency with which they happen. Perrey has collected voluminous materials, especially with reference to the influence exerted over earthquakes by the moon. He found that out of 3,654 earthquakes, 1,001 had occurred at times of new and full moon, and 1,753 at the first and third quarters. From these figures the inference was drawn that the moon affects the periodic recurrence of earthquakes, as she affects the ebb and flow of the tides, but the figures above given are only four per cent. of the whole, and therefore much too small a portion to give a sure basis for the theory. It was also pointed out that Perrey could not have arrived at any very different result, even if the moon really exerted a decided influence upon earthquakes; for he had treated one new and full moon just like another, whereas their real influence would vary considerably in intensity, according to the moon's distance from the earth, and position with respect to the equator. Later on, Schmidt investigated the earthquakes between the years 1766 and 1873, with reference to the moon's distance from the earth, and found that in the half-year when the moon is nearest the earth, 183 more days of earthquakes happened; and in the other half-year, when the moon was farthest from us, 180 less, than if earthquakes were entirely independent of the moon's distance. It is then proved that there are more earthquakes when the moon is near the earth, than when she is farther off. And there is also a season of frequency. Mallet's catalogue of the earthquakes happening between 800 and 1842 shews that the greatest number happen in January, and the smallest in June. Now in January the sun is nearest to the earth, and farthest from it in June. Here then is shewn another influence exerted in the same sense as that of the moon, and confirmed by twice as much evidence as could be collected in the former case.

In short, there is no longer any possibility of doubting that both sun and moon exert a demonstrable influence upon earthquakes, analogous to that which they exercise upon the ebb and flow of the tide. About a hundred years ago, this influence was spoken of by more than one scientist, and it was said



ERUPTION OF VESUVIUS, AUGUST 26, 1872.

that there was an actual ebb and flow within the centre of the earth: Perrey shared this opinion, and imagined that on the surface of the masses of liquid fire in the centre of our globe a mighty tidal wave swelled and broke against the solid crust. But the view met with no approval. Falb says that the influence of the sun and moon is by no means the sole, or even the chief, cause which produces earthquakes. They would occur, even if the attraction of sun and moon, which creates the tides, did not exist. All that the sun and moon do with respect to earthquakes is to create inequalities in the intensity and frequency of the phenomena. The true cause is to be recognised in the continuous cooling-down process of the fiery liquid matter inside the earth, with its necessary development of gases, and the pressure of the solid, contracting crust above. This process causes the injection of heated masses into the fissures of the cold earth crust, and the explosive action of these masses either creates more or less severe shaking and trembling of the earth's surface, or, if the explosion is intensified by the presence of water, breaks through the opposing strata altogether. It has long appeared probable that water plays an important part in volcanic eruptions. According to the theories we have just stated, there is sufficient force for the lava ejections, while the local irregularities and differences of frequency are explained in a natural and intelligible manner. When the subterranean ejections of lava are not able to break through the strata, and when therefore there is no communication with the surface of the earth, a shaking of the ground is all that results from the interior disturbance; but when the heated lava comes in contact with water, the result is an explosion which sends the mass or stream of lava to the surface of the earth. Upon this assumption a number of phenomena attendant upon earthquakes and volcanic eruptions are easily explained. As to the attractive (tidal) influence of sun and moon, it can only act as affecting the weight and pressure upon the lava, and must not be considered as directly acting upon the separate parts of the solid earth crust. This has been established by Schimdt's investigations in Athens. He found that earthquakes occur much more frequently with a low than with a high barometric pressure.

According to Falb's theory, the influence of sun and moon consists in increasing the frequency of earthquakes at certain times of the year; whereas if this influence did not exist, volcanic eruptions and earthquake disturbances would be more regularly distributed throughout the year.

If the centre of the earth is at present in a state of liquefaction, there is no difficulty in admitting that the sun and moon affect the periodic recurrence of earthquakes, as stated in the theories we have quoted; but it would be futile to lose sight of other influences, equally important and much more obvious, which also contribute to produce the same results. These are, as we have already stated, the falling in of hollow spaces underground, the perpetual upheavals of mountains, which necessitate a corresponding contraction of the earth crust, and the melting of soluble rock, etc., which often happens very suddenly, and occasions displacement, friction, and cleavage. Perhaps every earthquake in the Alpine range may be attributed to the latter cause. It has been emphatically demonstrated in recent investigations, that the earthquake focus always lies in districts where the strata are no longer horizontal, but disturbed; in "dislocation surfaces," that is, in surfaces on which displacements have occurred in past ages in the earth crust. Earthquakes shew that upheaval and contraction are still slowly progressing in uninterrupted action, bringing about as their result a continuous slipping, displacement, and convulsion of the earth crust. Of course there are also purely volcanic earthquakes; that is to say, earthquakes which precede and foretell volcanic eruptions; but these are only local in character, and shew unmistakable signs of their explosive nature. The grandest earthquakes, and those which extend over the widest area, teach us what the earth has suffered in those remote periods of time when the great mountains were first raised, and the processes of upheaval and contraction took place on a far larger scale than is the case at the present day.

THE INNER HEAT OF THE EARTH.

The difference of temperature produced by the sun upon the earth's surface is imperceptible at a very slight depth below the ground. First of all, the daily changes of temperature are said by Quetelet to disappear at the depth of four feet six inches below the surface. At much greater depth the yearly change of heat and cold is lost. A depth of from sixty-five to eighty feet must be reached before these annual changes disappear; the figures given, however, must not be taken too strictly, as they are sometimes affected by the construction of the ground and the free play of the atmosphere upon the surface. The stratum of earth which possesses an unvarying temperature is found in the tropics at a very slight depth below the surface; and this explains why the water in tropical springs generally has the same temperature as the average yearly temperature of the atmosphere. The heat of the sun penetrates the earth very slowly. In our own country the greatest heat of July does not descend six feet below the surface until the beginning of September; it reaches twelve feet below in the beginning of October, and twenty-four feet only in December. Conversely the smallest degree of heat in January descends six feet by the middle of March, twelve feet by the middle of April, and twenty-four feet by the middle of June. The time required by the heat received upon the surface of the earth to penetrate to a depth of twenty-four feet below is supposed to be about 150 days. Whenever the average yearly temperature falls below freezing point, the earth at a certain depth below the surface must necessarily be continually frozen. This zone of perpetual subterranean ice is found within a line drawn from Lapland to Tobolsk, intersecting Lake Baikal, north of the mouth of the Amoor to the coast. The same line starting from Norton Sound in North America, and turning to the south-east, runs by Lake Winipeg and the southern point of Hudson's Bay, ending at Nain, on the north-east coast of Labrador. Within this immense zone the ice may, it is true, melt in the upper strata during the continuous heat of the summer, thus rendering cultivation possible in certain places, but on digging deep the substratum of ice is always encountered. In the year 1828, a well was sunk at Iakutsk, but at a depth of fifty feet the temperature was 18° F. The works were afterwards continued with a view to scientific inquiry, and it was found that the temperature rose, but at a depth of 380 feet below the surface it had only reached 31° F. below zero. According to Middendorff's investigation, fluid water would not be reached before descending to 600 or 650 feet underground.

The remarkable fact that even in the cold climate of Iakutsk the temperature of the ground increased with the increase of depth only confirms the result of other experiments made within the temperate zones. As soon as the stratum of unvarying temperature is passed, an increase of heat is felt, and it becomes certain that the earth itself is a source of heat. This inner heat is not perceptible on the surface, but it increases with increasing depth at the average rate of 1·8 degree in 100 feet.

Kircher had already called attention, in 1664, to the fact that in deep strata below ground the air was warmer than upon the surface of the earth, but no accurate investigations were made before those instituted by Genson in the lead mines of Giromagny, in the Vosges, 1740. Five years later, Saussure examined the salt pits of Bex, Canton, Vaud, and d'Aubuisson; and in 1802, the temperature of the mines at Freiberg was found to increase by 1·8 degree for every additional descent of thirty or forty yards. And finally the temperature measurements taken in artesian wells have led to very accurate calculations, and established the general law that the deepest artesian wells yield the warmest water. Without giving a detailed list of the earlier experiments, it will be sufficient to mention the recent investigations made in sinking a shaft in rock-salt at Sperenberg to the unusual depth of 4,054 Rhenish feet, or 1,387 yards. This depth was attained without piercing any other kind of rock, and the calculations were made with the utmost care and precision. To take the temperature of the salt water at different depths, a thermometer specially adapted by Magnus, and called a geothermometer, was used. The observations taken by means of this instrument shew that when the stratum of unvarying temperature has been passed, there is an increase in warmth in proportion as a greater depth is reached, but that this increase is not strictly regular, and that in an increased depth of a hundred feet it varies from 32·3° to 35·9° Fahr. The heat rises from 52° Fahr. at the depth of a hundred feet to 118·5° at 4,040 feet.

These observations were made with great care, and with the best possible instruments; but the water temperatures of the various depths do not give what is really sought, namely, the temperature of the adjoining rock, because there is a constant circulation between the warmer and lighter water from below, and the heavier and colder fluid from above. This difficulty was overcome by observations made at the depth of 1,185 yards, in sinking a deeper shaft, eighteen feet long, and considerably narrower, the water in the narrower shaft being cut off from the rest, and its temperatures averaged. In this way the first measurement of the water in the narrow shaft gave a temperature of 114·8° Fahr., and that taken from all the water collectively, 107·3°; the second measurement of the water in the narrow shaft alone 114°; from all the water 107·8°. The important disturbing effect of the circulation between the warmer and colder waters was thus established, and the two temperatures being averaged were recorded, after the necessary corrections required by the action of Magnus' geothermometer, as 116° Fahr., which gives the true temperature of the rock.

It is most important to notice that the experiment at Sperenberg shews that there is no regular, uninterrupted increase of temperature corresponding to the increase of depth, but that the increase of heat occurs more slowly at very great depths; in other words, that the degrees of the geothermometer grow longer as it descends. The sinkings at Grenelle, near Paris, gave somewhat similar evidence, but with far less certainty. We are not, then, at liberty to assume with Humboldt, and with many other scientists of the present day, that the inner heat of the earth increases unchecked toward the centre, and that at the depth of a few miles below the surface the rocks are in a state of fusion. The only trustworthy conclusion to which we are at present led is that the increase of heat continues only to a moderate intensity, and that, at a depth of a few miles at the most, we should find a uniform temperature very different from the intense heat spoken of by Humboldt, Von Buch, and others. Nothing forces us to adopt the belief that the earth is still a liquid mass of fire enclosed in only a few miles of solid crust. It is true that the depths at which temperatures have been taken by the geothermometer are very insignificant when compared to half the diameter of the earth, but for that very reason the retardation of the degrees of increasing heat is the more startling. Can it be asserted that in approaching the hand nearer to the flame of a candle the ratio of warmth felt would decrease proportionately to the greater space through which the hand moved in going towards the light? If it were so, the source of heat would have greater power in proportion to its distance, and its effect would decrease as it was approached more nearly. But if the theory of a central fire be denied, the question immediately arises, to what then is the earth's inner heat to be ascribed? Is it to be sought in chemical processes? This view gains probability from the fact of the rapid rise of temperature observed in coal mines, which is most likely the result of the chemical transformations taking place in the coal strata.

But extensive as these strata may be, they are too insignificant to be put forward as the source of the earth's central heat. Another hypothesis has been put forward by Mohr. He tells us that every phenomenon observed in the explored strata of the earth may be completely accounted for by a temperature of about 560° Fahr., and that the cause of the earth's inner heat is the active force of the sun converted into heat. Vast quantities of distilled waters penetrate the earth every day, and return from it charged with earthy particles. By this process the weight of the earth is necessarily lessened, and it must at last sink under the load. But according to the law of conversion of energy, force produces heat; and if heat be considered as the thermal equivalent of force, it would, in falling from a height of one yard, produce 0·440 kilogram, or one pound, an amount of heat sufficient to raise the temperature of half a drachm of water by two degrees Fahrenheit. Practical experience furnishes many instances of heat instantaneously produced by suddenly checked motion. In laying the foundations of the railway bridge at Cologne, it frequently happened that wooden stakes became carbonised in the bed of the Rhine, and smoke ascended in bubbles from the water. The stakes had to be drawn up, and it was found in every instance that they had struck against some obstacle. They were burnt quite black, although the stratum was not thick. The rammer weighed twenty-five hundredweight, and fell sixty times a minute from three feet in height. It is impossible to believe that the falling processes taking place daily in the earth can continue without developing great heat; and any theory of the earth's inner heat which does not take them into account must be defective and false.

Mohr's hypothesis is ably argued, but it is not sufficient to account for the earth's inner heat. Another, and we think a more satisfactory, explanation is that which ascribes it to the contraction and condensation of the earth's crust. This supposition contradicts no fundamental law. According to Helmholtz, the radiation of the sun is balanced by the continuous falling of the sun's material towards the central point, or, in other words, by its condensation. Radiation takes place also from the earth, and it, as well as the sun, is condensing by contraction. If we turn to this source for an explanation of the central heat, we shall find the most harmonious agreement with every phenomenon which has as yet come within the scope of our observations.

Volcanoes: Hypotheses as to their Origin.

We all have a general idea of what is meant by volcanic phenomena, and yet many persons might feel some difficulty in giving a clear definition of volcanic action. Humboldt described volcanism as the reaction of the still liquid interior of the earth against the hard crust of the surface. Although the views of scientific men concerning the subject have changed considerably since this definition was given, it may yet be accepted with the amendment that volcanism is the reaction of *all* the central parts of the earth's interior against the surface. But this definition tells us nothing more than we can learn by the direct evidence of our senses. We see how from flat conical hills, called volcanoes, gases, melted rock or lava, and clouds of ash are brought to

Burning Pit in Dutweiler, in the Coal District of Saarbruck.

the surface through an opening in the rock, and distributed over the adjoining land; we acknowledge that such volcanic outbreaks are among the grandest and most terrible phenomena of the globe, but as to the true seat and essence of the power working within the volcano, not even the most patient and careful local investigations can tell us anything definite. Volcanic phenomena thus form one of the most difficult, as well as most interesting, features of geology. In the last ten years of the past century, volcanoes were looked upon as holding but an unimportant place in the earth's history, and were thought to be caused by the conflagration of the coal strata. It is an undoubted fact that such conflagrations do take place. In the year 1741, a mine at Wettin, in Magdeburg, ignited and burnt for thirty years. The carelessness of a workman is said to have caused the great fire in Walker's mine on the Tyne; and in this case also the fire lasted for thirty years. In the seventeenth century, a shepherd accidentally set fire to a coal mine near Dutweiler; all attempts to extinguish it by water were ineffectual, and it burnt on for a century and more. At times these underground conflagrations present every appearance of a volcanic eruption on a small scale. In the year 1759, in an asphalt pit, the workmen came upon a spring of water containing rock oil. The oil ignited, and the fire breaking out threw down two of the men, scorching their hair. After a few hours a violent explosion was heard, and the tiled roof of the building above the shaft was dashed to a considerable distance.

Von Buch, when engaged in his investigations of Vesuvius, became suspicious of this conflagration theory. There were no signs of coal beds to be found anywhere near the mountain; and towards the end of the last century a truer and wider theory was sought in explanation of the phenomena. Continued investigations led both Von Buch and Humboldt to look for the origin of volcanic action in the incandescent liquid centre of the earth's interior, and shewed that a volcanic eruption never takes place except where there is a communication between these heated masses of the interior and the outer atmosphere. A great support to this theory is furnished by the fact that volcanoes appear to be wholly independent of climatic influences, and, like the central heat of the earth, indicate the existence of some universal cause. It was therefore but a step in advance to assume, both for the gradual increase of temperature below the surface, and for the volcanic action which sends up masses of molten rock, one and the same cause, namely, a fiery liquid interior of earth reacting upon a thin, cold, enclosing crust. No one who accepts the theory of a central liquid fire can escape from being led to this conclusion; but those who believe that the centre of the earth has long ago cooled and hardened are forced to seek for some other explanation of volcanism. And, as Mallet remarks, whoever is able to point out the true source of the high temperature of volcanoes holds the key to the whole mystery. Let us see whether this key has as yet been found.

Mohr asserts that volcanoes are nothing more than localities where, through continued sinking movements of the earth's crust, heat is produced, which becomes intense enough to melt the silica. Mallet agrees with Prevost, and sees the origin of volcanism in the contractions of the earth's crust. The heat, he says, which creates volcanic activity throughout the world, is produced locally by conversion of the mechanical energy of contraction and compression in different places. Against this hypothesis it is said that while the process of compression is so slow and gradual, it would be difficult for the heat so created to reach any high degree of intensity, although it must be owned that certain local meltings have been found in actual existence, which are apparently due to no other cause than the one under consideration. Preyer considers that the earth's centre, or "magma," is not fluid, but is hard and solid, owing to the great pressure exercised upon it. If, however, the pressure were relaxed, this centre would soften, and become capable of eruptive action. Siemens lends the weight of his great authority to the theory that volcanism can only be explained by the supposition of a solid earth crust resting upon a plastic or heated liquid mass; but he adds that this hypothesis at once presents a new problem, for which a solution must be sought. The difficulty lies in the great elevation of the continents, and the long continuous risings of vast stretches of land. The difference of altitude between the high plateaus of Asia and the bottom of the Pacific Ocean amounts, when stated at the lowest computation, to 13,000 yards, which, by making allowance for the difference in weight of the land and water, may be reduced to 10,000 yards, representing a difference of about a thousand atmospheres. From the relatively slight solidity known to be possessed by the earth's crust, it appears inevitable that the Asiatic plateaus and the other continents should settle down into a position of equilibrium, while the beds of the oceans should rise to the same position. If the scientific world will not or cannot abandon the theory of a central liquid fire, they must assume that the necessary hydrostatic equilibrium is restored by the difference of the specific gravities of the various formations of rock which form the mainland and the bed of the oceans, and that the latter consists of heavier stone than the continents, or that the plastic masses beneath the outer crust are of a sufficient thickness, and of such various specific gravity, as to be able to equalize the difference of pressure. The continuous rising of the land would then be only the local development of this difference and its equalization.

And thus Science at the present moment finds herself face to face with the unknown, when she grapples with the question of the origin of volcanism. No one can as yet tell us with any degree of certainty, whether we see in volcanoes the remains of that primeval heat created at the first act of the earth's rotation, or whether the heat is due to a cause nearer at hand, to the persistent contraction and compression of the earth's crust, aided in part by certain chemical processes. The latter theory, which restricts volcanic phenomena to the upper strata of the crust of the earth, and supposes the local accumulation of incandescent liquid masses of rock, which occasionally come to the surface, seems to us now the more probable. Even the eruptions of volcanoes which are near each other never indicate a subterranean connection between their focuses, but rather shews that each volcano has its own volcanic focus.

Geographical Distribution of Volcanoes—Central and Linear Volcanoes.

A glance at the map shews at once that volcanoes always rise near the coasts and on islands, while the interior of the continents shews no trace of their presence. Along the margins of the greater cleavages of the earth's crust, for instance on the border of the continents, especially on both sides of the Pacific, we find long rows of smoking craters, but we look for them in vain in the interior of the continents, on the immense plateau in the interior of Asia, or in the centre of Africa or North America. Where, on the other hand, at a distance from the present coast line, we find in the interior proofs of former volcanic antiquity, the nature of the surrounding territory will shew that the sea formerly covered it, and that we are in the neighbourhood of former seashores or islands. A striking example of this is furnished by the extinguished volcanoes of the Eifel. Their greatest activity took place when the sea still reached the outlines of the mountain chain, and this activity continued for a long time after the configuration of the territory had considerably changed.

The valleys in the Eifel, as well as those in the Auvergne, had already nearly their present shape when the volcanoes became extinct. This can be positively proved on some spots of the Eifel. Where the lava streams flowed down neighbouring valleys, the valleys must have been in existence to receive them when the eruptions took place; and as many of these valleys have not greatly altered in form since that time, their formation must have been, upon the whole, complete at the time of the eruption.

With respect to the local distribution of earthquakes, it is well to classify them, as Von Buch has done, into the two groups of central and linear volcanoes. In the former class are comprised those volcanoes which have one principal cone, surrounded by a group of vents. To the central volcanoes, which are much less numerous than the linear, belong Vesuvius, the volcanoes of Iceland, Mount Etna, and the Peak of Teneriffe. Linear volcanoes are those which are found along the same line of direction, rising like gigantic chimneys, at no great distance apart. Among the linear volcanoes are the Mexican volcanic chain, the parallel range of the plateau of Quito, the remarkable Chilian range, the Kamtchatka volcanoes, the Aleutian, Kurile, and Japanese volcanic islands in the Pacific, the burning mountain of the Moluccas, and Philippines, Sunda Island, and the Marianas. The linear form is that of the typical volcano; it appears not only on a large scale, but asserts itself in miniature by the grouping of parasitic cones ranged like satellites, often in

STROMBOLI IN ACTION.

straight parallel lines to the principal range. Just as these lesser cones have been formed along the fissures of the principal volcanoes, so in like manner have the latter regularly arisen along the fissures of the earth's crust, the open spaces of which form the true vents of the eruptive outbreaks.

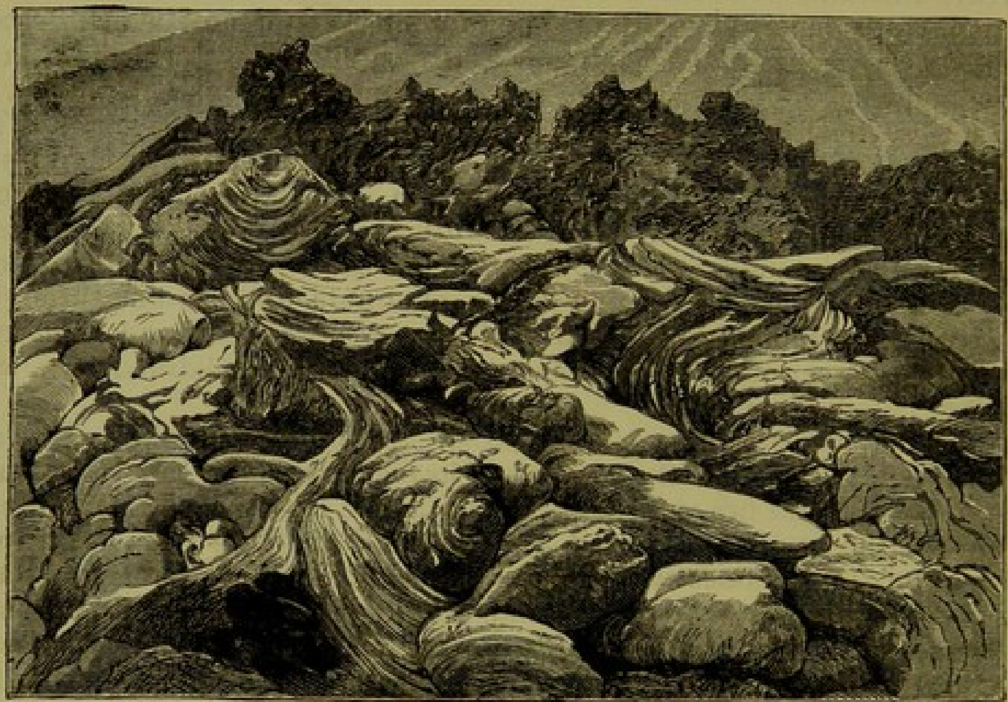
It is difficult to state with any certainty the number of volcanoes at present in action; on the one hand, because many a cone which has for a long time been classed among extinct volcanoes suddenly wakens into action, and proves that it has only been lying dormant, and also because we do not yet know all the existing volcanoes. It is, however, of but little importance whether the earth has at present 270 active volcanoes, and 672 altogether, as Fuchs found out, or whether there may be half a hundred more. We will only add, therefore, that, not including Iceland, there are four active volcanoes in Europe—Vesuvius, Stromboli, Vulcano, and Etna; besides which there are eleven in Iceland and Jan Mayen, ninety-three in Asia, twenty-six in Africa, forty-six in North America and the Aleutian Islands, twenty-seven in Central America and the Antilles, thirty-one in South America, seven in Australia, and twenty-four in the islands scattered over the oceans.

Form and Construction of Volcanoes.

Even those who have never seen an actual volcano are familiar with the pictured representations of the fire-breathing mountains, if only from the numerous paintings of Etna and Vesuvius. In fact, the true form of a volcano is seen to best advantage in the isolated cones of Etna, Vesuvius, and the Peak of Teneriffe, although many volcanoes take the form of ridges like that of the Pichincha, with its fiery gulf at one end of the chain. There is great difference also in the size of volcanoes; many, and among them some of the most dangerous, are mere hills, while others might take rank among the greatest mountains of the world. The most important part of the volcano is the crater, or funnel-shaped opening of a channel or gulf which descends deep below the ground. The crater is generally found in the highest part of the mountain, sometimes with another of almost equal size close by, and sometimes surrounded by a group or circle of smaller openings. Thus Waltershausen, the great authority with respect to Etna, found 700 small cones upon the mountain-side, many of them with craters. In some cases the volcano has no true crater, and the eruptions take place through fissures on the slopes of the mountain. This is also the case with ordinary volcanoes, as in certain eruptions of Etna, when the mountain appears cut through, as with a red-hot knife, near the summit. In periods of repose, and in dormant or extinct volcanoes, the crater is closed with masses of solidified lava, which are melted before an eruption.

According to the views of our earlier geologists, Hamilton, Dolomieu and others, each volcano is the product of its own eruptions. It was assumed that streams of liquid fire welled upward from the centre of the earth, breaking through the upper strata, and accumulating near the place of eruption. At the same time masses were hurled up with explosive force, and falling back, became by mutual friction and breakage changed into the small rounded scoriæ called *lapilli*. After repeated eruptions, a conical mound was formed with alternate layers of lava and ashes, which fell radiating from the vent on all sides. We must assume, says Spalazani, that there have been at least as many eruptions as we find layers of lava. In this manner most volcanic mountains have been formed. At first there is merely the accumulated produce of the first eruption; then comes a second, then a third, the mass increasing in proportion to the amount ejected from the crater. There is no doubt that the giant bulk of Etna was formed, developed, and outspread in this way. The volcanoes of the Lipari and other volcanic islands had the same method of formation, as had also Mount Vesuvius; but it must not be forgotten that certain small cones on the side slopes of Mount Etna, such as Monte Nuovo and Monte Rosso, were the work of one eruption only.

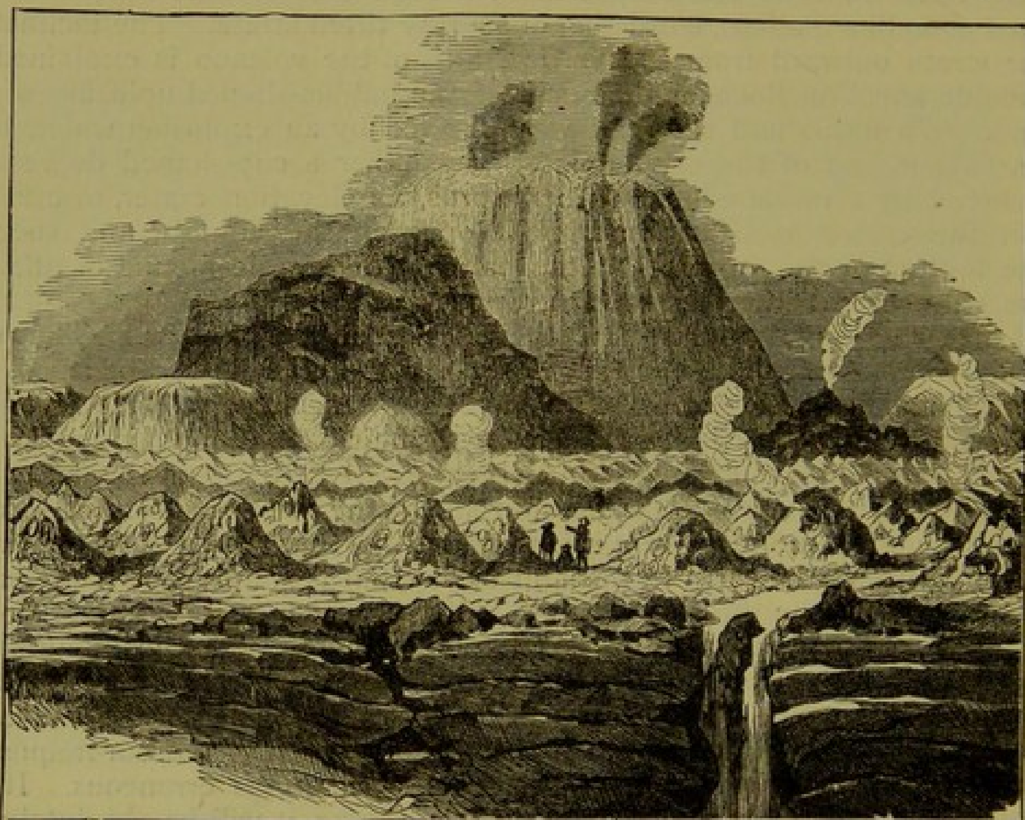
When Von Buch visited Mount Vesuvius in the year 1799, he made the following observations: "The volcano originally rose like an island in the sea, as is proved by the petrifactions of corals and shells, such as are at present found in the Gulf of Naples. These petrifactions lie imbedded in the tufa which covers the plain surrounding the mountain. Another proof of its having risen from the sea is found by its regular distribution over so large a surface, the surface itself being even now but little raised above the sea level. If the tufa covering were removed, it would leave the whole mountain surrounded by the sea. It appears highly probable that the volcano was connected with the mainland by means of ejected ashes. Now, if Vesuvius was once an island in the sea, its elevation is more easily understood. Streams of lava are an impossibility under water. They solidify as soon as they come in contact with water, and the next eruption spreads a second coating of lava over them. Thus, in course of time, lava strata are formed, and the volcano rises with its solid indestructible core of lava from the surface of the ocean. The rising slopes are covered with alternate layers of ashes and lava (tufa), as often as new outbreaks eject them from the interior, and spread them over the surface. The hollow spaces thus formed below the ground will not tend to any speedy falling in of the mountain." In considering this kind of volcanic formation, we must not lose sight of the fact, that it is not the result



LAVA FIELD IN VESUVIUS.

of one single eruption such as created Monte Nuovo, and that it was not raised suddenly from the bottom of the sea, as Santorin and the new island in the Azores. The latter have all existed for centuries above the abyss which they must have opened below them, but Vesuvius is the creation of a long succession of eruptions which have heaped up substances of the most different kinds. It is known that, later on, Von Buch relinquished his theory, which we have stated above, and joined De Beaumont and Humboldt in trying to explain the origin of the volcanoes by elevation. The results of a great but local exertion of force, says Humboldt, expanding vapours either uplift separate portions of the earth's crust in conical, unbroken masses, rich in felspar, trachyte, and dolerite, such as Chimborazo and the Puy de Dome; or the uplifted strata are broken through and bent outward in such a manner as to create on the corresponding inner side a steep edge of rock, which thus becomes the margin of an elevation crater. If the volcano (which is by no means always the case) is raised from the bottom of the sea, it determines the whole formation of the uplifted island. Such is the origin of the circular form of Palma, so well described by Von Buch, and of Nisyros in the Ægean Sea. Sometimes half of the circular edge is broken through, and in the bay so formed busy corals have built up their cellular dwelling places. Even on the mainland, elevation craters are often filled with water, and lend a peculiar charm to the surrounding landscape. The expanded vapours escape through the crater, and the uplifted mass falls back and closes up the opening, only formed by such exertions of force. Thus no volcano is created. A true volcano demands a permanent opening connecting the interior of the mountain with the upper air. The reaction of the interior against the surface lasts within it during long periods of time. Where the tokens of the first outbreak—the whole framework, as it may be called—are in a state of preservation, the volcano rises from an elevation crater; a high wall of rock surrounds the isolated cone like a circus, consisting of sharply tilted strata. The inclination of the strata outward from the vertical axis of the volcano is explained by Humboldt and Von Buch, as the result of the bubble-shaped uplifting of the ground. When this had set in, it was followed by an explosion which blew off the upper part of the elevation, forming either a cup-shaped depression, surrounded by a raised edge, in other words, an elevation crater, or creating within the crater itself a conical hill open at the summit, and shewing at the bottom of this opening of the crater a perishable mound of tufa and scoriæ, with several eruptive cones of various sizes.

Later research, however, has decided against this view. The very volcanic formations which formed the oldest and, as it was believed, the best evidence of the elevation theory have been used against that theory, to attack, confute, and overthrow it. The great black castellated mound which appeared on the night of the 29th of September, 1759, between the flame and smoke and ashes, on the place where now stands the Mexican volcano, Jorullo, was, according to more modern scientists, neither hurled nor forced upward from the centre of the earth to the light of day, but is simply the accumulation of lava thrown out by the first eruption. If the earth is raised at once on any given place by subterranean force, all the strata of which the mountain so raised is composed will necessarily be found lying symmetrically to each other. If strata can be found having a contrary inclination, this fact, if it stand alone, is with difficulty reconciled to the elevation theory; and if it occur frequently, it leads to the inevitable conclusion that the theory is erroneous. If, for example, the earth is uplifted in the form of a cone, it will be absolutely impossible to find strata upon this cone which, instead of running toward the summit, fall away diagonally toward the base of the cone. Now there are many such stubborn layers found in volcanoes, which it is impossible to bring into accordance with the theory of elevation. If a subterranean force presses against a surface of sixteen or more square miles, and raises the ground, the earth so raised, supposing the surface to be reached, would seldom or never present the appearance of the so-called elevation craters; such a mass could not be raised as one unbroken cone, but at the nearest approach would shew only circular tilted strata, or "horns," bending toward each other, and only connected together at the base. The radiating fissures, the so-called barrancos, which run star-shaped from the summit of the cone or elevation crater, would, if an upheaval took place round an axis, be of very different size from what we see them to be; they would, instead of forming fissures upon the surface, tear asunder the whole uplifted cone from summit to base. Again, they would be widest at the summit, and decrease toward the foot of the mountain. Now the actual fact does not correspond with this description. The fissures are widest at the base, and decrease in width and depth as they approach the summit. The elevation theory explains this remarkable phenomenon by the excavating power of water rushing down the slopes, and no doubt that power is quite sufficient to account for every appearance presented by the barrancos. But by this explanation the partisans of elevation throw away their chief support; for if aqueous erosion has so transformed the barrancos as to make their greatest size found in those parts of the mountain where nothing of the kind was originally seen as the result of the elevation, what is to prevent our going a step further, and maintaining that the existence of the barrancos is wholly and solely due to the action of water? The supposition is plausible in itself, and if it can be proved, the whole theory of elevation falls to the ground.



MOUNT JORULLO.

Lyell and Hartung have been able to find these proofs, and have thereby given the death-blow to the elevation theory. The ravines dug up by rain-water down the sides of volcanic mountains in Java are found even upon mountains which have no crater, and in such wonderful regularity as to leave no doubt of their watery origin. In the volcano of Gunung Merabu, the whole side of the ascent is hollowed out, and the gulf of the crater is seen passing through the centre of the mountain.

And there are still other arguments weighing strongly against the elevation theory. First of all, the fact that the volcano does not consist of the same material as the mountain range, but is made up of the results of its own action. To explain this difficulty, it was contended that the lavas were horizontally deposited and solidified before the eruption, and the phenomenon was claimed as evidence for the elevation theory. For, according to De Beaumont, lava could never harden into basalt at a greater angle of inclination than from three to five degrees; and as the average inclination of the slopes of a volcano is from thirty to thirty-five degrees, it was necessary to assume that the lava had become solid before the period of elevation. "The whole mass of Mount Etna is not covered with uniform layers of basalt, but with layers of lava, and the Cantal in France is not clothed with heterogeneous streams of lava, but with homogeneous layers of basalt." "The slopes of both have a nearly equal inclination," says Von Buch, "and the conclusion is that the basaltic covering of the Cantal must have been solidified while in a horizontal position; and if it now lies at almost the same inclination as the lava streams of Etna, it must have been raised from the centre of the mountain after it had hardened." Von Buch then adds, "that it is only exceptionally that the lavas of Etna shew the thickness of basalt, as, for instance, near Torre di Griso, where the fact attracts much attention from its rarity. The circumstances, therefore, of the solidification must have been of influence." The next thing to be done is to decide upon the nature of this influence. There are evidently two existing possibilities. Either the degree of fluidity possessed by the lava is always and everywhere the same, or it is variable. In the first place, the construction of the solidified lava will be principally determined by the inclination of the slope on which the hardening takes place; but in the latter case the degree of fluidity will be of great importance, although the course of the influence of the angle of inclination will also be felt. Now we must not imagine that burning liquid lava is fluid in the sense in which water or quicksilver is fluid; it is under all circumstances very tough and thick. Scrope compares it aptly to the consistency of sugar or syrup in the last stage of their manufacture. In both cases the masses consist of crystalline or granulated particles, to which a certain mobility is imparted by the fluid matter between the particles. He compares the extremely tough fibrous or vitreous lava to barley sugar, and the finely crystallised lava, rich in augite and felspar, and the porphyritic and granite trachyte, to sugar-candy. Lava streams have been

IN THE CRATER OF POPOCATEPETL.

seen to rush down the slopes of Vesuvius in fifteen minutes, while others were crawling slowly downward, and stiffening half-way between base and summit, frequently advancing at the rate only of a few feet per hour. The method of movement is as various as its speed. In some cases the lava flows smoothly on, filling up every cleft and fissure, and in others it descends with more of a rolling movement, stiffening very quickly on the outer surface. It is clear, then, that to a certain extent the lava may be independent of the angle of inclination over which it flows; that it assumes various forms in stiffening, including that of the basalt mentioned by Von Buch at the Torre di Griso. But it is also proved by abundance of direct testimony, that it is capable of solidification upon a much steeper slope than that asserted by the partisans of the elevation theory. We need only remember that De Beaumont himself declares the present cone of Vesuvius to be the creation of successive eruptions, while the Somma, the remains of an old volcano, from the centre of which Vesuvius probably issued in the eruption of the year 79 A.D., rose by

MOUNT ETNA—PRINCIPAL CRATER.

elevation. Singularly interesting and decisive in this respect are the bottle-shaped lava columns of Hawaii, which rise forty feet high, and were produced solely by an eruption resembling a fountain.

Another objection to the theory of elevation bases itself on the fact that, in spite of the enormous masses of lava, tufa, and scoriæ ejected by eruptions, the volume of the volcano never perceptibly increases, and is comparatively insignificant. The eruptive cone of Vesuvius, according to Humboldt and Von Buch, grows no higher, but is indeed at times lower than it has already been. Now, the growth of a volcano depends of course in part upon the amount ejected, and partly also upon the violence of the eruptions. The latter may be distinguished under three forms. The eruption may consist of a more or less permanent outflow of lava from the top of the crater, or small quantities of ashes and rapilli may be ejected. In both these cases the cone of the volcano will increase. But the phenomena may also take another form. The volcano may for a time lie dormant, and even appear to be extinct, as was the case with Vesuvius in the year 79. But the repose is only apparent. The volcanic forces have been accumulating during the long period of inactivity to colossal dimensions, and at length overpower the load resting upon them; and, as in a paroxysmal eruption, the whole summit of the mountain is blown away, and by the new arrangement of masses, some of which fall back through the chimney of the volcano, while others are carried to a great distance, the height of the mountain must be lessened. A new cone then arises from the wreck of the old, and from the outflow of fresh lava into the circus of rock left round the former crater. Great influence is also exerted by the denudation carried on by the destructive agencies of air and water, especially when the mound heaped up round the crater consists only of ashes and rubbish. The volcano increases in size only in proportion to the relative absence of violence in the eruption, and to the quantity of the lava. An example will suffice to shew the immense extent and volume of the outflowing lava. The Icelandic volcano, Skaptar Jökull, poured out two mighty streams of lava in 1783, one of them fifty miles in length and fifteen wide in several places; the other forty miles long, and here and there seven miles wide. These streams were more than 500 feet deep, and their collective volume six times as great as that of Mont Blanc.

According to Parrot's estimation, Etna has thrown out, from the year 1175 to 1787, as much lava as would form seventy mountains of the same size as Vesuvius. Surely this enormous mass does not fit in at all with Von Buch's theory.

Volcanoes are now classified as strato, or stratified, and homogeneous. The former are formed by the fiery liquid masses pressed upward from the interior of the earth, and coming into contact with water as they are forced through rifts and fissures of the surface crust. Tremendous explosions then ensue, and the stratified volcano is formed by the ashes and lapilli ejected from the vent. Alternate layers of solid and liquid volcanic material are deposited, but the shallow cone is always the product of the eruption itself. The volcano studied by Hochstetter upon the isthmus of Auckland may be considered a typical stratified volcano. Its substratum is formed by an extremely shallow cone of tufa, where the first eruptions occurred under the sea. Above this is a lava cone, formed of streams which have flowed down on every side of the orifice, and enclosed layers of ash and scoriæ. Above this comes the steepest part of the mountain, composed of dry materials, such as ashes, etc., supporting the actual crater of the volcano, and being very perishable.

Homogeneous volcanoes arise where there has been no contact with water, and therefore no explosion or breaking up of the material ejected. The lava streams in this case are thick, and flow quietly down in burning streams, forming curved and bell-shaped mounds lying one above another. The mounds have been compared to onions placed upside down upon the ground. The channel through which the thick magma reached the surface lies in the centre of the mountain. The whole Schloszberg, at Teplitz, is a type of this formation, consisting of a single mass of phonolite, shallow and dome-shaped; the lava having risen from the depth below where it is standing.

Volcanic phenomena have been imitated in miniature, with a view to a scientific representation of their various processes. When sulphur is melted in water under a pressure of two or three atmospheres, it absorbs a certain quantity of water, and has the property of allowing the water so dissolved to escape as it cools, and hardens gradually, and in the form of steam. If the sulphur, which has been melted in this manner, is poured in larger quantities ($1\frac{1}{2}$ to 2 cwt.) into wooden moulds of sufficient depth, a crust forms over them as they cool, and through the opening, which must be kept free in the crust, periodic eruptions of sulphur will take place during the process of cooling, accompanied by exhalations or explosions of steam, and in the course of an hour and a half a perfect miniature representation of a volcanic cone of sulphur will be built up, the cone being from one to one and a half foot in diameter at the base, and two or three inches high.

The model volcanoes formed in this experiment exhibit on a small scale every characteristic of a volcanic cone gradually raised by streams of lava.

The phenomena thus observed tend to explain or confirm many facts which have been remarked in real volcanoes. For instance, if the process of eruption is interrupted by the artificial opening of a second orifice, hollow cones are formed by the molten lava forced upward by steam pressure in the opening of the crater, having melted again part of the central mass formed by previous eruptions, and now sinking back again as the process is interrupted. If these hollow cones are flattened, and the eruptions allowed to begin again, the model of younger cone formations is attained, surrounded by a rocky wall, as Vesuvius is by Somma, or the Peak of Teneriffe by the so-called circus. It may therefore be assumed that those circular ridges have also arisen by the falling in of hollow volcanic cones formed during a temporary suspension of volcanic action. If the process of eruption is allowed to continue without interruption, massive cones with closed craters, are formed, the melted sulphur pressed upward from below forming as it finally cools a solid core of sulphur inside the outer stratified layers.

Phenomena of Eruptions.

We have already stated that it is in some cases difficult, if not impossible, to decide whether a volcano is only dormant or actually extinct. Until the year 79 of the Christian era, Vesuvius was regarded with reason as an extinct volcano, for no outbreak of its hidden fires had been known within historic record. Indeed, it was only a supposition, based upon the burnt appearance of certain parts of the crater, that caused it to be reckoned in Strabo's day among the number of former fire-mountains. We learn from Martial, that its slopes were covered with groves and vineyards dedicated to Venus and Hercules. Even the occasional earthquakes of the district were not dangerous, until the one which occurred in the year 63 A.D. The giant Etna, on the other hand, was always known as a volcano, but it was thought in Nero's times to be dying out; indeed, Aelian asserted the summit was lowering, and could not be seen at such a great distance out at sea as formerly. The great volcanoes of the Andes are at times quiescent for centuries, giving not the slightest sign of the hidden power sleeping within them. As a general rule, the higher volcanoes are found to have fewer eruptions than the lower. Stromboli and Guacamayo are in a state of almost uninterrupted activity, while Cotopaxi and the Peak of Teneriffe are but seldom the scene of eruptions. It is easily intelligible that the giants among volcanoes have fewer eruptions; for the re-melting of the hardened lava columns of the central vent requires a far higher degree of heat in a volcano 12,000 or 18,000 feet high than in a low hill; also it needs a considerably greater force to upheave the molten masses to the crater top of Cotopaxi than to the summit of Vesuvius. These considerations tend to give us a true idea of the volcano during the whole course of its activity. At the beginning of their existence, most volcanoes have certainly broken out into frequent eruptions; but with the increasing height of their cones, erruptions must become rarer, and we can imagine heights at which, as in the case of geyser springs, they no longer take place. The volcanic central force then exerts itself for an indefinitely long period upon the rifts and chasms of the interior, "until these wounds upon the earth's body are entirely healed."

On passing to the consideration of the actual phenomena of volcanic eruptions, we find no dead uniformity; essential likeness and agreement exist as a matter of course, but not to such a degree as to prevent every volcano from possessing a special individuality and character of its own. Generally a lofty column of smoke issues from the crater, and, like a great waving streamer, shews the direction of the atmospheric current. Exhalations of sulphur, hydrogen, carbonic acid, chlorine, boracic acid, and other gases announce the action within the volcano; sometimes also there are the warning signals of earthquakes and subterranean thunders. The floor of the crater rises, and mounds of ashes and ejectamenta are formed within. In 1816 and 1818, an immense cone appeared above the edge of the crater of Vesuvius, and was visible for a great distance, so as to be taken by the uninitiated for the true summit of the mountain. In the eruption of February, 1822, it became still larger; but in the night of the 22nd of October of the same year the whole cone, which had then risen to the height of 400 feet, fell in with a loud report; and on the following day began a terrible eruption, which lasted for twelve days. Volcanoes which are found within the region of perpetual snow sometimes prelude their eruptions by the melting of their snowy covering. This phenomenon is wonderfully grand when seen on the conical peak of Cotopaxi. Before the smoke is visible in the rarified atmosphere which surrounds the summit and the opening of the crater, the walls of the cone of scoriæ glow red hot from within, and the whole mountain is a dark mass of ominous and awful blackness. At each outbreak, stones and ashes are hurled up to dizzy heights in the air. The escaping watery vapours condense into clouds of steam, which settle down upon the mountain peak, and are pierced through and through with sudden lightnings. Aerial thunder is heard between the sharp cracks and heavy roaring of the underground explosions. Floods of water fall in resistless masses from the broken clouds, darkened with the whirling ashes; runlets of water are changed to torrent streams, chased down the mountain-side by cataracts of stones, tufa, and volcanic bombs; while the dull monotonous grey of the falling ashes begins to bury and engulph all beneath its deepening shroud. At night the reflection of the burning masses within the crater turns the heavy vapour masses into clouds of flame, so as to give the impression that columns of fire are issuing from the crater. Not until the fury of the outbreak has reached its crisis do the snake-like lava streams break forth, slowly creeping or rushing with winged speed from crater or lateral fissure. Wherever it meets with vegetation, the lava sends up heavy clouds of smoke; where it falls upon a human dwelling, there is a sudden outbreak of lurid flame, and all is over.

At times, and especially in the volcanoes of the South American Andes, streams of burning mud flow down the mountains, desolating all they touch. When these streams consist of volcanic ashes and water, they harden into tufa, or the Neapolitan puzzolana. When Cotopaxi was raging from the 25th to the 29th of June, 1877, the whole district round was darkened by showers of sand, so that the day did not dawn for Quito until the 27th of that month. All Ecuador was terrified by the roaring of the mountain; but more terrible still were the mud streams which rushed down with frightful rapidity. One of them, coming from the north, devastated the valley of Chillo, causing the death of 400 human beings, and the ruin of all their property. Another mud stream rolled towards the plains of Callo and Rumibamba, threatening

Latakunga, and causing the death of 300 persons. The priest of Mulalo told Wolf, the geologist, that on the approach of the stream he ascended the tower of the church to obtain a better view of the disaster, and saw a procession of about twenty people on horseback only a few thousand paces from the town. They appeared to be the members of one or two rich families, and consisted of men, women, children, and servants. The jaded beasts were being urged forward with all possible speed ; but it was too late ; the flood overtook them, and in an instant every trace of men and horses disappeared. These mud streams do not arise from the crater ; they are caused by the sudden melting of the snow, which is in its turn produced by the masses of molten lava issuing on all sides from the crater, so that immense clumps of ice and blocks of burning lava are carried down side by side.

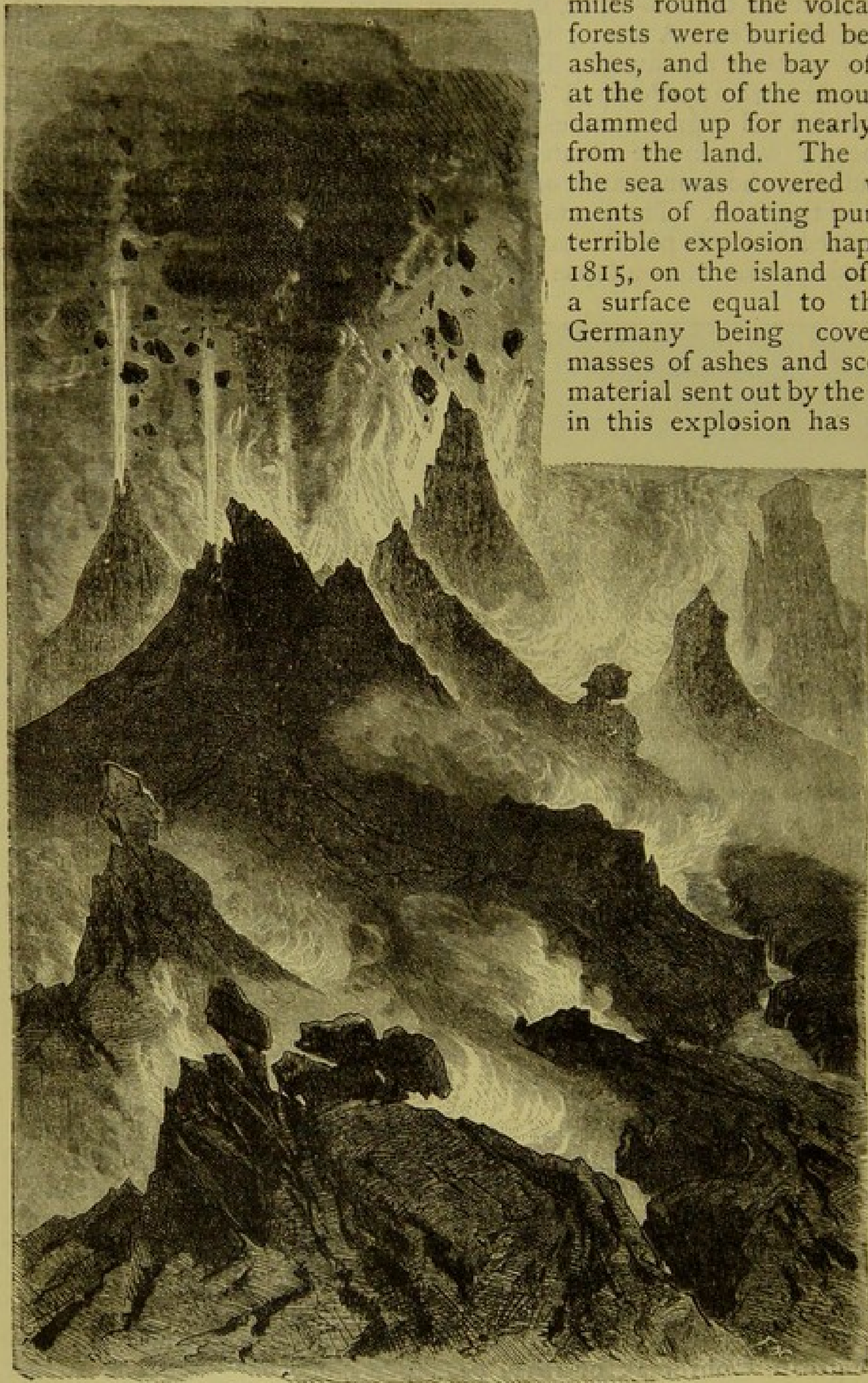
The inhabitants of Guatemala distinguish between fire and water volcanoes. The Volcan de Aqua, or water volcano, ejects from time to time volumes of water amid violent earthquakes and continued underground thunder. The town of Guatemala, founded near it by the Spaniards in the year 1524, was entirely destroyed by an eruption in 1527. The inhabitants fled, and built their new city, New Guatemala, at the base of the adjoining fire volcano, which in its turn annihilated the town in 1773. Mud eruptions have also taken place in Hawaii, especially in the fearful outbreak of Mauna Loa. In the neighbourhood of the crater of Kilauea, the earth suddenly opened in the midst of a beautiful and richly cultivated valley, sending out a torrent of red mud which destroyed the whole place, and caused the death of all the living creatures within its range.

The masses of sand and ashes sent out by the volcano are nothing but broken and powdered particles of lava torn up by the detonating explosion, and stiffening as they come in contact with the air. This is proved by the microscopic investigation of handfuls of the ashes shewing the visible growth of crystals, and the glass enclosed by them ; and by the coating of the crystals, and the hollow spaces within the glass and crystals themselves. These masses are sometimes hurled upwards to the height of more than 5,000 feet ; nay, they have been known to reach a height of 9,000 or 10,000 feet, forming a heavy column above the crater. This column rises vertically from the orifice of the crater, and spreads out at the top in a flat disc.

The grand spectacle thus presented was described by the younger Pliny as resembling a lofty pine tree, with high, overshadowing branches. The quantity of ashes ejected is often very great, and is carried by the wind to long distances from the mountain. The terrible darkness brooding over the doomed cities of Herculaneum and Pompeii, as they sank to their ruin, was caused by clouds of ashes. Pliny the younger gives us a detailed description of the catastrophe. His uncle was in command of the fleet stationed in the harbour of Misenum, when a cloud of strange form appeared above the horizon. He immediately got into a rowing boat to investigate the singular appearance, leaving his nephew behind. The vessel was steered for Retina, and came there within the range of the falling showers of stones and ashes. Meanwhile Misenum was shaken by a great earthquake ; a black cloud, laden with thunder and lightnings, rolled up from Vesuvius, and turned day into night. A fine rain of ashes began to descend, and all the inhabitants took to flight through the profound darkness. The sky was veiled by clouds of ashes from Rome to Egypt. The elder Pliny meanwhile had gone to Stabia to reassure the terrified people, and was quietly sleeping through the dreadful night, when he was awakened with the news that the falling ashes shewed signs of breaking down the house in which he was resting. It was scarcely safer out of doors, for large pieces of pumice-stone were falling from the darkened sky. Pliny went to the sea-shore, sat down upon an outspread cloak, and drank a cup of water. A strong smell of sulphur roused him, but he fell back, and his servants ran away. Two days afterwards his body was found. The catastrophe began in Pompeii with the fall of showers of lapilli as large as walnuts, which fell in great masses, and lay several yards deep in the streets. The townspeople were in the theatre, and made their escape into the open air; but hundreds, who from avarice or want of thought returned to their houses, were buried in the ruins. The strata of ashes, which the succeeding outbursts of rain converted into soft plastic masses, enveloped the bodies of the unhappy people so closely, that after a lapse of 1,800 years the spaces once filled by

SHOWER OF ASHES FROM MOUNT VESUVIUS IN 1822.

the corpses, which have since crumbled into dust, have been filled with gypsum, and form faithful casts of the entombed inhabitants. Herculaneum and one or two small places in the neighbourhood met with the same fate. Herculaneum, it is true, is still covered with a stream of lava; but the disaster of the year 79 was principally due to the showers of ashes. It is very probable that the south and south-western part of the cone of Vesuvius was blown completely away, and that the remaining portion of the crater entrenchment forms Mount Somma at the present day. Since the destruction of Herculaneum and Pompeii, the greatest outbreak of ashes took place in the October of 1822. The mass then ejected was, according to Humboldt, three times as great as that of all the ashes known to have fallen since volcanic eruptions began to be carefully noted in Italy. The small volcano, Cosiguina, in Central America, sent out a cloud of ashes in 1835, which produced, perhaps, more than 50,000 million cubic yards of matter. The air was darkened for more than 100 miles round the volcano, whole forests were buried beneath the ashes, and the bay of Fonseca, at the foot of the mountain, was dammed up for nearly 900 feet from the land. The surface of the sea was covered with fragments of floating pumice. A terrible explosion happened in 1815, on the island of Simboro, a surface equal to that of all Germany being covered with masses of ashes and scoriæ. The material sent out by the Sumbawa in this explosion has been estimated at 2,000 million cubic yards. If, therefore, the volcanoes are on the one hand built up by the enormous outflow of lava, their tops are on the other hand occasionally blown to pieces by violent eruptions, the greater part of the summit being broken into dust, and carried away by the wind. The lava masses of the larger volcanoes generally escape from lateral fissures, instead of from the central crater. Before the eruption, the lava is found in



Eruption of Vesuvius on April 16th, 1834.

a boiling state at the bottom of the crater, where it seethes and bubbles at an immense heat, causing many slight eruptions within the orifice. The so-called Hell of the Masaya, in Nicaragua, presents the appearance of a sea of fire; but the grandest example of this kind of volcano is afforded by the Kilauea, in Hawaii. This crater, which is the largest volcanic opening in the world, is found on the eastern slope of the Mauna Loa. In the year 1823 it was visited by Ellis, and described as a crescent-shaped abyss of more than two miles in length, a mile wide, and 800 feet deep. The bottom was filled with lava, and the south-west and northern parts were in a state of liquid fire, boiling and roaring with waves of heated lava, from the midst of which fifty-one craters stood out like islands in an ocean of fire. From twenty-two of the craters rose columns of smoke or pyramids of flaming fire, while many of them sent out blocks of molten lava which ran down the black walls of rock in red-hot streams into the hissing floods below. The sides of the crater fell vertically down 400 feet, on to a foundation of black solid lava, below which they descended again for another 400 feet. The upper lava bed had evidently emptied itself into the gulf below. The sight at night, when the fogs and clouds had lifted, was most striking. The heaving mass of lava roared and swelled like a sea of molten metal, while the leaping flames played above the surface, and shining sulphurous blue or Strontian red cast weird lights upon the crater, which from time to time hurled up red-hot stones and blocks of glowing lava with terrific detonations. Close to the crater lay blocks of grey stone, many tons in weight, which had obviously been cast out from the principal opening; and farther away was a second large crater, about half the size of the one described, and separated from it by a tongue of land 100 yards wide. Its slopes were covered with trees and brushwood, but the bottom was filled with lava, partly molten and partly almost cold.

In the month of May, 1840, the whole abyss became again a raging sea of fire, breaking against the rock, and sending up large masses of stone. It broke through the Caldera on the 30th of May, and flowed on underground until it reached a forest, which it entirely destroyed. It then went on its way sometimes above ground and sometimes below, until on the 3rd of June the whole mass poured itself over a cliff forty or fifty feet high into the sea—a cataract of fire as wide and deep as Niagara. Loud hissings and detonations accompanied the fall; the lava, as it touched the water, was changed into minute particles of dust and sand, whirled upward by the clouds of steam, and scattered in fine showers on all sides. A new sandbank was formed close to the island, and farther out to sea three hills of ashes and scoriæ, 200 to 300 feet high, were raised above the surface. The burning stream flowed without ceasing for three weeks, heating the sea for twenty miles along the coast, and changing night into day along the whole eastern coast of Hawaii. The glare could be seen for more than 100 miles out at sea, and at the distance of forty miles from the coast fine print could be read at midnight. The length of this terrific lava stream from Kilauea to the sea was about forty miles, the depth varied from ten to a hundred feet, and the width from one to five miles, according to the configuration of the ground. On its passage it filled up valleys, melted hills as if they were made of wax, and burnt up great forests like feathers held in a flame of fire. During the tremendous discharges the crater of Kilauea sank about 300 feet; its fires were almost extinguished, and nothing but a lake was left in the midst of the great Caldera.

The collective mass of lava sent out by Kilauea is estimated by Dana as more than 5,000 million cubic yards. The great chasm, 1,200 feet deep, was almost entirely emptied. Slowly, however, it began to fill again, and there was another discharge in 1855. Ten years later the crater was found to be much reduced in circumference; it was possible to descend it to a depth of 142 yards, and spend the night in the neighbourhood of a wide sea of lava, 328 yards in diameter.

Principal Crater of Mount Etna, and Southern Group of Craters seen from Monte Rosso.

Among European volcanoes, Etna is the most remarkable for its size and the masses of lava which it ejects. Vesuvius dwindles into insignificance when compared with the Sicilian mountain, the base of which is thirty miles in diameter. It rises grandly from the plain, an isolated cone with a gentle slope, and is called by the inhabitants simply "la montagna." A crescent-shaped precipice, open toward the sea, discloses the interior of the volcano, built up of strata of lava. This valley, known as Val del Bove, is probably the remains of the original crater. The present crater lies to the west, upon a mound of ashes, which rises above the plateau of the summit. The lower slopes of Etna are of luxuriant fertility; beyond them is a belt of woodland, and not until this central region has been crossed does the real fire-mountain begin to rise. About three hundred thousand persons inhabit the slopes of the mountain; and yet the area is so great, that the smoking crater rises far away, and is separated from the highest dwelling house by rocky solitudes. Numerous smaller eruptive cones rise on the mountain flanks, and have at times sent out desolating streams of lava. On the south side of the volcano, the lava stream of 1669, which reached Catania and the sea itself, destroyed fourteen towns and villages, and has put an end to the cultivation of the district up to the present day. The village of Nicolosi, which is situated near the upper boundary of the cultivated zone, yet shews the traces of the furious outbreak of 1669, when the great chasm opened from Monte Frumento near the summit down to the piles known as Monte Rossi. This is the highest eruptive cone which has been thrown up within historic times, and consists of two cones covered with red ash, the base being one mile and three-quarters wide. The height is 840 feet. It has two principal craters, and several smaller ones formed along the line, which correspond to the chasm of 1669. The roar and thunder of the mountain is said to have been heard in former times miles away. The double cone was built up by an outflow of ash and lava, which lasted for nearly three months. A part of the chasm, called the Grotta della Palombe, is still visible, and can be reached by ladders. Above Nicolosi rises the belt of wood for about a mile in width; the slope is from five to eight degrees; this is the zone of the conical hills traced by Sartorius upon his map of Etna. There are two hundred of these hills, corresponding to as many lateral eruptions. While the principal crater rages and casts out burning stones, the lava pours forth from these openings in the side. The relief of this mountain zone is a tangled chaos of hills; most of them are situated upon the south and south-east side of the mountains, either standing alone or in scattered lines and clusters. Some of them have distinct craters; others shew signs of recent change, but the same vent seems never to have been opened in two eruptions, each outbreak sealing up its passage and shaft with solid lava, so that the giant body of the mountain must be pierced through with countless corridors of lava. The desolating floods increase near the summit. Starting from Nicolosi, the path lies for about an hour's climb through a deep bed of black ashes, between two rows of craters. Then is reached the solid lava bed of 1537, poured out after twelve days' thundering from the neighbourhood of the Schima del Asino; and ending where thirty-two years later Monte Rossi arose. A fresh stream of lava flowed over this bed in 1766.

One of the most wonderful eruptions was that of Sangay, in the eastern Cordilleras of South America, in 1874, when a stream of lava flowed forth quietly for a whole year. It issued from the eastern side of a crater formed within the interior of the principal crater. In a sheet of bright liquid fire it poured over the deposits formed near the bed of the old crater, and rushed at great speed down the outer slope of the steep cone. The lava must have been unusually thin; for not a trace of scoriæ is found upon the spot, though the signs of the moving streams are very distinct. Lower down the slopes, tufa was seen floating upon the stream, at first merely dimming its intense glare, but after a time standing out as black stones from the liquid fire around them. Lower down again these stones form a stratum intersected with light red lines, where the lava shews through the bed of tufa. The stream then divided into several branches, the light being much paler, and the fragments of stone rolling over each other, while the lava was raised up in an immense mass, till it suddenly broke by its own weight, and poured down the precipitous slopes in a shower of stones and dust. Again and again was this spectacle repeated; while from the summit rose a sheaf of flame, scattering fiery spray and small red-hot stones over the mountain-sides. Down the centre of a broad bed of black ashes, where the snow had been cleared by the fire, the red lava poured from the chasm, cutting through the deep snow, and reaching to a distance of 3,600 to 3,700 yards. The discharge is said to have continued with equal force for several years.

The lava quickly cools as it flows down, and is covered with a scaly or cindery crust, which for awhile moves on with the burning mass beneath, with a sound like that of broken glass. Sometimes the liquid lava flows away from under the crust, leaving a raised coat of ash, which breaks up and crumbles into dust.

Many a life has been saved against all hope by this sudden cooling of the lava. Thus, only a few people lost their lives by the terrible lava stream which destroyed Torre del Greco, causing the sea to boil and the tar of the ships in the harbour to melt. Many persons who had escaped to the upper storeys of the houses saved themselves on the following day; the women even carrying gunpowder across the still burning lava. In 1779, Hamilton and his guide walked across a stream of lava, which was still actually moving, although only slowly. But notwithstanding that the outer surface of the lava, owing to its quick radiation, is so soon covered by a crust, that men can cross it in safety, and that masses of snow and ice are said to remain intact beneath the lava beds of Etna, yet the heat of the central masses endures for long periods of time. The lava of Jorullo, for instance, smoked for sixty-seven years.

There are two varieties of lava which assume different forms, in proportion to the greater or less proportion of steam which they contain. The one, sometimes called stony or scoriaceous, sends out larger masses of vapour. Its scoriæ are rugged and angular, breaking up into lumps, and rolling over and over with a clattering sound. At its lower part, this kind of stream is a mere heap of loose wreck. It flows quickly, and cools with equal rapidity, while its glow is less intense because of the rapid formation of tufa. The second variety may be called fibrous lava. It flows slowly with little development of steam. At first a tough pliant skin is formed above it, which contracts and wrinkles with the movement of the heated mass beneath. Sometimes the pressure from below causes it to expand into bubble-shaped risings, and break up into fibrous particles. The fibrous lava flows without any of the continuous rushing and noise of the scoriaceous; but when the crust bursts open, it gives out a clinking, metallic sound. It is very long in cooling, and its streams harden down into a coherent mass.

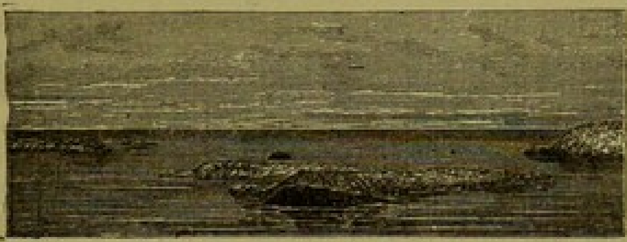
When no actual eruption takes place, the volcanic action reveals itself by the exhalation of gaseous vapours. Besides the aqueous vapours rising as fumaroles from the fissures, or escaping from the surface of the solidified lava, streams of hydrochloric acid, sulphuric acid, and sulphuretted hydrogen rise up, and deposit incrustations of salts and sulphur upon the sides of the crater, or salmiak crystals where the lava covers cultivated or wood land. In the great crater of the island volcano of the Solfatara, whose funnel-shaped sides glimmer with vivid red and yellow through the heavy clouds of steam, workmen are busy collecting sulphur and borax. Exhalations of carbonic acid gas, called mofettes, are the last signs of volcanic action. The Dog's Grotto in Naples, the Valley of Death in Jura, a small crater where no plant can grow, and the floor of which is strewn with the skeletons of animals, are localities where a continued exhalation of carbonic acid takes place, and this heavier gas forms a thick stratum on the ground. Near the Neapolitan Lago d'Ansanto, where once stood the Roman temple, dedicated to Juno Mephitis, the gaseous exhalations of hydrogen and carbonic acid still rise with great violence. The waters of the mofette are surrounded by a ridge of hard mud. When Wolf visited the Lago d'Ansanto, in May, 1869, the water was nearly dried up, only a small pool remaining in the middle of the crater-like opening, upon the surface of which mud bubbles about a foot in diameter rose and whirled violently round in eddying circles. The greatest quantity of gas, however, did not rise from this pool, but from a vertical fissure near it, three inches wide, whence it issued with such violence that substances thrown down the opening were dashed out to a height of fifteen to twenty feet. As Wolf stooped down to pick up his hat, which had fallen to the ground; his mouth, when two feet from the ground, entered into the stratum of carbonic acid, and he began to lose consciousness. Similar irrespirable strata have been examined on the floor of the cave of Susaki, on the isthmus of Corinth, where the gas can bê stirred up in waves like any other fluid, and becomes visible by its movement. Plants and animals die immediately from its contact. These exhalations, which are the last signs of volcanic action, sometimes last through whole ages beyond historic times; but some have been known to die away, or at least to be sensibly diminished; as, for instance, in the crater of Averno (the Lake Avernus), across which, according to the testimony of the ancients, no bird could fly and live.

There are, so far as we know, no trustworthy signs to give warning of an approaching volcanic eruption, or to tell us whether the eruption will be slight or violent. According to recent statistics, it is found that most eruptions happen during the summer months, both in the northern and in the southern hemispheres. A splendid observatory has been erected upon Mount Vesuvius, with a view to scientific observations, from which Palmieri has for years watched every movement of the mountain. It stands in a relatively safe position upon the ridge of Monte di Canteroni, near the hermitage of Il Salvatore. This ridge separates the valleys of Fosso Grande and Fosso della Vetrana. The observatory is, however, by no means out of danger in great eruptions; indeed, it was believed to be threatened in the outbreak of 1872; but the dauntless Diego Franco remained at his post through the terrible night of the 26th of April, when the chasm opened at Atrio, and the whole upper part of the Val della Vetrana was smoking with burning lava, and surrounded by the roaring seething flames. Unfortunately the gain for science, and especially for the scientific knowledge of volcanoes, has been very slight. Nothing can be learned concerning volcanic eruptions from an observatory near the crater, which may not be equally well observed at a distance. The seismograph, which indicates the trembling of the earth, is not of much value, and stands moreover upon a floor which vibrates at every tread. It would be better if these instruments were erected upon suitable stations round the mountain.

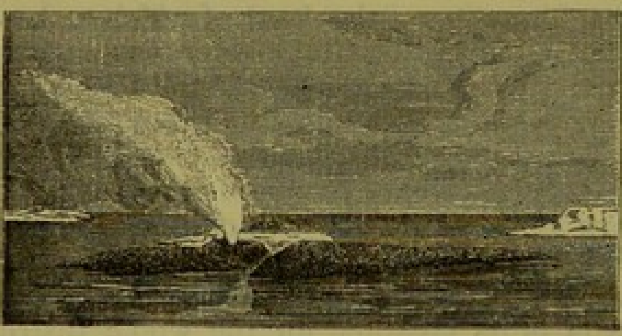
Formation of New Volcanoes.

The formation of new volcanoes is by no means of very rare occurrence within the historic period. The oldest formation of that kind, of which we have any knowledge, is supposed to be the hill near the Gulf of Hermione, on the peninsula of Methana, said to have arisen in the year 282 B.C. Strabo mentions the heat, the smell of sulphur, and the rending off of masses of rock; he tells us also that the sea was in commotion for more than half a mile. Without dwelling upon vague and doubtful traditions from China and Japan, we may mention the creation of Monte Nuovo at Naples, a cone which appeared first toward the end of September, 1538, after the neighbourhood had been shaken with earthquakes during the whole preceding year. Unfortunately it was impossible to observe the phenomena of its creation, for the whole district round was enveloped in smoke and ashes. Francisco del Nero writes, however, to Benino, "Imagine such a number of rockets sent up from the Castle of St. Angelo, that, as they fell, they formed a mountain of equal height to San Silvestro in Tusculano, and you will have some idea of the chasm which threw up so many stones." Between Toluca and Colima in Mexico, violent earthquake and underground thunder were heard in the year 1759, and on the 29th of September the volcano of Jorullo was formed, from the fissures of which floods of lava were poured forth, while two small brooks disappeared within the crater, and afterwards came to the surface in another place as hot springs. A surface of from fifty to sixty square miles, the *Malpays*, was entirely destroyed, and forty-four years after the eruption Humboldt found it still covered with numerous small volcanic cones, from which smoke was rising, and which were called by the inhabitants *hornitos* (ovens). At the present day the ovens are burnt out, and the lava brought into contact with the atmosphere has crumbled away into fertile earth. The Jorullo has not had an outbreak since its first formation ; but the little volcano of Izalko in Salvador, which was formed on the 29th of March, 1793, has continued in a state of almost uninterrupted activity. The lava which it has poured out to build up its own cone, from 1793 to 1865, is estimated at 27,000,000 cubic yards. New volcanoes break forth less frequently upon the mainland than upon islands; for example, the volcanoes of the Aleutians and Sobrina in the Azores, and in 1831, the island Ferdinandea, south of Sicily. More closely investigated have been the phenomena at Santorin, where for the last two thousand years, as far as history and tradition extend, Nature has never ceased in her attempts to form volcanoes.

The most recent formations at Santorin took place at the beginning of the year 1866. The first sign of the return of volcanic action on Nea Kaimeni was perceived by a watchman who lived there in the winter, and noticed some cracks in his house on the 26th of January. He made his report at Thera, and Dr. Dekilaga came to the place, followed soon afterwards by a Greek commission, with J. Schmidt. On the 30th of January, a dull sound was heard along the east coast of Nea Kaimeni ; the next day rifts opened in the ground ; the noises increased in loudness and frequency ; bubbles of gas rose to the surface of the sea, and white vapours ascended along the coast. In the afternoon the edges of the harbour began slowly to sink. At five o'clock on the morning of the 1st of February, a bright flame, from four to five yards high, and ten to fifteen yards wide at the base, suddenly appeared along the west coast of the harbour, disappearing again at six o'clock. The rifts in the ground increased, and the smell of sulphur and sulphuretted hydrogen was perceptible. The earth trembled continuously, and sank slowly beneath the agitated waters of the harbour, which sent up clouds of steam, and here and there were covered with green patches. On the 2nd of February, the commotion in the harbour increased in violence, the raging sea was lukewarm, and fires were seen at night along the west side of the harbour. In the two following days the action became more violent, the smoke was denser, and at half-past four in the morning a rock stood in the place of the flame, and visibly became larger and larger. On the same day boards of sunken ships were cast up. The island could be approached within ten paces from the land side. The increase of size and growth from the centre outward developed so rapidly, that the eye could scarcely follow and note the manner in which the blocks arranged themselves to form the whole. Delikaga says that the island expanded like a soap bubble ; but, according to the observations made, the island was rather rampart shaped than circular. It increased rapidly, and at night the volcano looked like a burning pile of coals lighting up the smoke clouds, until the fumarole rose like the tail of a fiery comet. On the 5th of February, the new volcanic hill, which had appeared so unexpectedly in the harbour, received the name of Georgios. On the 6th and 7th of February it increased more rapidly than on the preceding days. On the 11th the volcanic action slightly relaxed, and the Greek commision sent by the Greek minister, at the request of Julius Schmidt, began their observations.

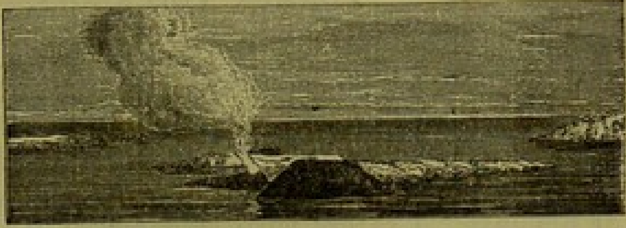


New Formations at Santorin before the Eruption of 1866.

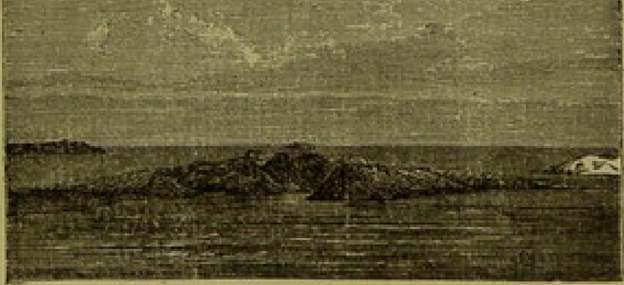


New Formations at Santorin, February, 1867.

The first eruption witnessed by the members took place on the evening of the 10th of February, when a sheaf of dark-red stones rose like a fiery palm tree to the height of 100 yards. In the night of the 13th of February, several members of the commission ascended the cone to the north of the Georgios, and saw the whole surface red hot, and small leaping flames of vivid blue-green playing in the chasm. On the 17th of February the commission sailed round the island, which was then quietly smoking, and afterwards visited the Fumarole Aphroessa, which extends for a mile along the open sea, and had risen 100 yards since the 13th of February. A few days later, on the 20th of February, a fearful eruption took place on the Georgios, while the members of the commission were but 197 yards from the summit, and only escaped a terrible death as if by a miracle. There was no question of personal observation, for every object was wrapped in profound darkness by the falling ashes and hailstorm of lapilli. Hasty flight was the only thing to be thought of. The outbreak was preceded by an appalling roar of thunder, which drove the inhabitants of Thera and Theracia from their houses in terror. Schmidt says that his last distinct memory is that he saw the summit of the Georgios slowly rise; while at the side, and underneath the dark clouds, very large blocks of stone were thrown out in flat curves, without much apparent force. They fell slowly, and close to the summit. He then took refuge within the fissure of a crater; but his clothes were on fire, and he had some trouble in extinguishing the flames. As soon as it grew rather quieter and lighter, he hurried through the old western crater, which was torn and rent by deep fissures. He found that here, too, and on the northern side, the vegetation was set on fire by the lapilli and burning stones. From many places on the adjoining Mikra Kaimeni tall columns of smoke were issuing upward. On the 21st of February there was a loud explosion, and a great quantity of ashes rose to ten times the height of the cone. At about ten o'clock in the evening the volcano was quiet, and lighted up by a pale gleam; but early on the following morning the smoke and thunder began again, the fiery vapours rising to five times the height of the cone. At seven o'clock the next day the volcano was quiet, with a great development of smoke. At two o'clock in the morning of the 28th a fearful eruption broke out again, covering the Nea and Mikra Kaimeni with burning fragments. Then followed a few days of comparative quiet; but on the 9th of March was heard for the first time that true underground thunder which makes any indication as to direction impossible. This was repeated several times on the 10th of March and the following days. On the 26th the commission left Santorin, but a great number of scientific men remained behind; among others, Von Seebach, who found Aphroessa and Georgios in great commotion on the 30th of March, although the eruptions did not take place at the same time. Indeed, the two volcanoes had already been pronounced to be entirely independent of each other. Since the 19th of March, Aphroessa and Nea Kaimeni had united. The volcanic action continued with varying intensity to the end of 1867. In the middle of January, 1867, the extent of the new lava bed was 1,000 yards long and wide; the height of the Georgios had reached 340 feet; and the whole mass of lava raised above water was more than 100 million cubic yards. Red, yellow, and (more rarely) blue flames appeared upon the summit, and the incessant eruptions casting up ashes and smoke were visible at Crete and the Cyclades. No detailed observations were made in the spring of 1868, but it is known that the eruption continued without cessation. On the 21st of June, Lieutenant Leyer, of the French frigate *Themis*, saw on the south point of the new lava a reflection of fire *under the water*, at the very place where Schmidt had heard a dull boiling sound from the depth of about twenty-eight fathoms on the 6th of January. Very little was heard of the volcano in 1869, but the following year was full of interest. On the 18th of April, 1870, at nine in the morning, the summit of the mountain was blown off amid loud roars and claps of thunder, and all the phenomena observed in 1866 were repeated on a grander scale. On the 15th of May, Captain Tupman measured the height of the Georgios, and found it to be 156 yards. On the 30th of May there was a violent eruption, sending out clouds of ashes 3,000 yards high. In 1871, the



New Formations at Santorin. Eruption of March, 1867.



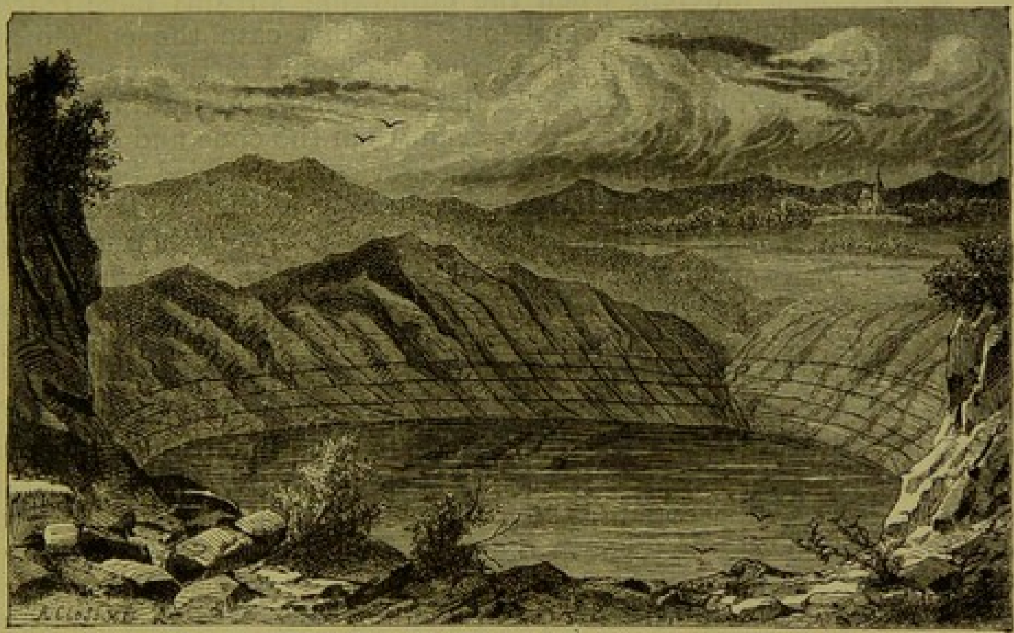
New Formations at Santorin after the Eruption of 1867.

activity was sensibly diminished; several visitors ascended the crater, and found it covered inside with large blocks of lava, and sending out columns of smoke. All that was recorded in 1872 was simply that the volcanic action was nearly extinguished. On the 7th of December, the architect, Paul Ziller, ascended the northern cone of the volcano. Lofty white fumaroles, he tells us, were rising on the western edge, very few near the crater, and many on the eastern and southern slopes. There was a strong smell of sulphur. No sound was heard, except now and then the rushing escape of a fumarole. The ground was warm, and everything that met the eye seemed burning hot. There was no true crater, but several conical holes were seen on the plateau of the summit, of which the centre one was filled with large irregular blocks of stone.

Former Volcanoes.—Volcanic Ruins.

Volcanoes are found in several parts of the earth which have never been seen in eruption since the historic period began, while the streams of lava and deposits of ashes and tufa furnish clear evidence of volcanic action in a remote past. First among this class of volcanoes is the rocky district of the Eifel. The observer finds here every familiar sign of volcanic activity, and can study them at his ease. Craters with streams of lava, mounds of scoriæ, circular pools, some filled with water, some lying half moor, half swamp, surrounded by their wall of tufa. These pools are perplexing phenomena. Sometimes they appear like sunken caldrons, with unbroken entrenchments, and at others the entrenchment is altogether wanting or interrupted by a trench serving as inlet and outlet. Many may be regarded as crater lakes, especially those which are well filled with water; and a few have been artificially drained. In many of them the connection between their crater-like depression and the stratified deposits of loose tufa lying round them is so clearly established, that even where the encircling ridge is broken down, and the edge of the pool shews nothing but the bare mountain rock, it is beyond a doubt that the masses of tufa lying near have been cast out of the pool itself. In this case the partially distributed tufa near the rent of the crater is not easily accounted for, as it is equally difficult to look upon it as an original deposit or to regard it as an effect of later disturbance. The partial protrusion of the bare rock corresponds naturally enough with the view that the tufa owes its origin to an outbreak which has had the effect of the springing of a mine, blowing up the fragments as it were, and leaving a funnel-shaped opening behind. This idea is borne out by the great quantity of fragments of the material of the mountain, *i.e.*, Devonian slate, which are mixed with the tufa in such proportions as sometimes to be its predominant ingredient. These pools are found also in other places. Lake Pavin, in Auvergne, is a similar formation, and so are the craters of the Alban Mountains and several *meres* in Java. They may be regarded as the beginnings of stratified volcanoes, which would have built themselves above them in repeated eruptions. A worthy pendant to the volcanic Eifel is Auvergne, with its strata of scoriæ and tufa, its streams of lava, and its domes of basalt. The latter often present the appearance of crater mounds, from which the outflowing lava has exploded or melted a part of the conical covering, so as to leave only a crescent-shaped entrenchment. Many a cone, such, for instance, as that of Mont d'Or or the Cantal, has been opened by erosion; and in the interior or neck of the crater can be seen an isolated phonolite column, which has survived the attacks of air and water by which its more yielding envelope was washed away. In the department of Hérault, near the mouth of the river of that name, rises the volcano of Agde. Isolated parts of the surroundings of this extinct fire-mountain lie almost on the sea level, and formerly the volcano must have risen from the sea. The former crater entrenchment is broken up into ruins. The upper part of the old volcano is a heap of loose lapilli, below which are solid beds of lava. The base of the mountain is formed with tufa. As far as can be now ascertained, the mountain must have sent out in remote ages two vast streams of lava, on one of which the little town of Agde now stands.

Italy presents us with several instances of extinct volcanoes: the Euganeen of the Lombard plain; many rents and crater lakes along the western slopes of the Apennines; the Alban mountain range and the immense crater of Rocca Monfina; and lastly, the circular volcanic mountains to the west of Naples, which present an appearance similar to that observable in the moon. Altogether there are twenty-nine crater cones in the district of which we are speaking; among them are the Solfatara, which still breathes out sulphurous fumes, but has shewn no eruptive activity since the year 1198,



THE WEINGELD MERE.

Monte Nuovo, and the ring-shaped Astroni. The creation of Monte Nuovo, the Mofetti, and the Solfatara testify to the volcanic fire slumbering deep below the surface.

Volcanoes belong to the most rapidly perishing mountains of the earth. As soon as the period of eruptive action is over, decay immediately sets in, and develops the more quickly, not only in proportion to the loose nature of the rocky cone, which is built up of ashes and other perishable ejected matter, but also by the action of denudation from without, and gaseous vapours which force their way from within through every cleft and fissure, corroding and disintegrating all within their reach. Geologically speaking, therefore, there are no old volcanoes to be found, although in the earlier ages of our world's history volcanic activity must have been far greater than it is at present. Even comparatively young formations have disappeared, with their eruptive cones, and left no trace behind but the lava fields which tell the story of past changes. The volcanoes of Auvergne shew the process of decay in all its phases. The study of these and similar volcanic ruins is not only important for the explanation which it gives us of the fire-mountains themselves, but it is also of use to teach us how to find traces of other craters which have left behind them more or less distinct marks of former action.

In recent times, Suoz has done much for the explanation of the typical form of volcanic remains. He starts from the theory that every eruption must break out through a more or less vertical channel of lava. Now if a volcano has been the scene of many eruptions, and has afterwards undergone considerable denudation, all its upper parts which rest upon the cone of ashes itself are quickly washed away or broken up, owing to their great friability; and unless they find protection between the star-shaped ridges, remains of later outbreaks are carried away as sand and *débris*. If, moreover, this process of denudation sets in below the level of the plain on which the original cone of ashes stood, the ends of the streams will be separated from these upper parts; and if the original foundation of the ends of these streams consists also of loose, friable material, the ends will be completely destroyed. The case is of course different when the outflowing streams have reached hard rock, such as limestone or sandstone. In this case the ends of the streams, separated from their original starting point, and resting upon a solid substratum of rock, may, in the form of isolated mounds, testify through long periods of time to former volcanic action, even when the cone and crater have long since disappeared, and the radiated lava crevices are buried beneath new formations. It is well known that many isolated basaltic mountains, once considered to be independent volcanoes, are merely, as their columnar fissures testify, fragments of former lava streams. The typical form, therefore, of an extinct volcano ought to shew a star-shaped group of raised ridges, surrounded by separate mounds, and formed either wholly or upon their summit of the same materials as the ridges themselves.

Such a formation is found in the northern half of the Euganee. The trachyte eruptions are principally the product of one independent volcano, which, judging by its base, must have equalled Etna in size. Later processes of destruction, however, occurred far below the level of the original eruptive cone, so that in most of the valleys older stratified formations appear. A beautiful instance of this typical arrangement of volcanic remains may be seen in the extinct volcano of Prisen, in Bohemia. An immense plateau of tufa rises like a shallow mound, and is intersected with channels of eruptive rock converging towards a centre in the interior of the plateau. Round the plateau rise hills entirely built up of solid eruptive masses. These dome-shaped rocks have generally the form of ridges, radiating from the plateau. They at once suggest the thought that they were originally streams of lava flowing from a crater, which rose where the tufa plateau now stands. The crater has long since perished by erosion, and the ridges rise like lofty mountain ridges round the tufa plateau which has replaced the former crater.

Mud Volcanoes.

Apart from the true volcano is the class of conical mounds rising only a few yards in height, and breaking out from time to time in eruptions very similar in many respects to those of the great fire-mountains. Like the latter, these smaller mounds are generally found upon islands and coasts of the mainland. The Macaluba, near Girgenti, in Sicily, is a mud cone of about fifty yards high. Smaller cones, only a yard and a half high, and having funnel-shaped depressions on their summits, are ranged on its plateau. In all these craters a greyish mass of liquid clay rises and bubbles. Forced upward by the gases below the surface, it rises like a bubble, and bursts with a loud report, ejecting a large quantity of mud. This is the ordinary state of development, but from every two to six years eruptions break forth on a larger scale. The earth trembles for miles round, and the eruption of stones and mud is accompanied by heavy rumbling thunder and dense vapours rising hundreds of feet in the air.

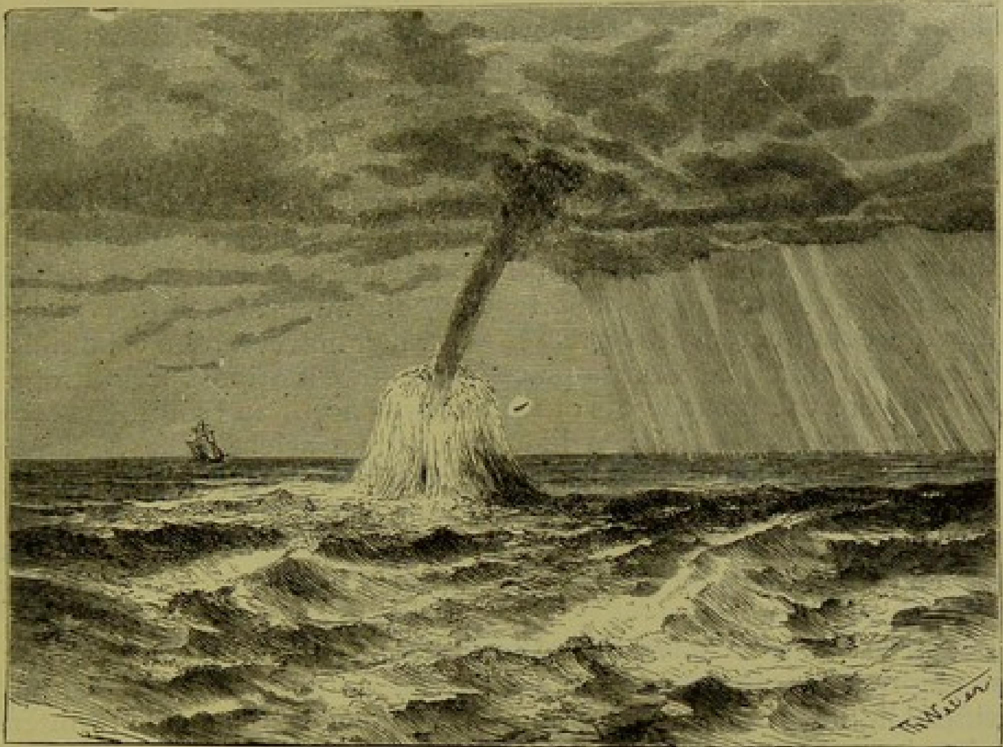
After long-continued rains, the smaller cones of the Macaluba are entirely washed away, leaving only semi-liquid bubbling masses, which gradually build up a new cone of ejected matter.

In the peninsula of Apscheron, naphtha rises, together with the carburetted hydrogen, from the ground near the mud volcanoes, and the salt water of the latter is generally covered with thick dark-brown naphtha, which is carried down the hills, and hardens over their surface into a bituminous mass.

The mud volcano of Prekla, rising about eighty yards high, on the peninsula of Taman, in the Black Sea, broke out in eruption in 1794. Earthquake, columns of fire from the crater, and the outflow of six streams of mud, attended this catastrophe, the amount of mud thrown out being estimated at more than twenty million cubic feet. Other great eruptions have broken forth from the volcano. On the 26th of April, 1818, a new mud volcano broke through a mass of *débris* which until then had been supposed to be a burial ground. Large blocks of the foundation of a great building were hurled upward to the surface, and from an inscription upon one of the stones carried some distance away by the streams of mud, it was found that it belonged to a temple built in the fourth century before the Christian era. The mud volcano, Küll-Tepe, in Taman, broke through an old burial ground, for upon its upper cone were found fragments of urns and amphoræ. On the flat undulating plain of the mud volcano at Boshie Promysl, Schneider found numbers of bones, fragments of pottery, and portions of human skeletons, which had been probably cast up in some unusually violent eruption. Hundreds of cones in various stages of development were seen upon the plateau, sending from their craters exhalations of very dark naphtha, carburetted hydrogen, and streams of thin liquid mud; the whole formation shewing signs of slight but unresting volcanic action. But proofs were not wanting that sometimes the expanded gases force their way upward in terrible explosions; for streams of solidified mud were found in deep channels washed out by the rain, and opening on the lower slopes of the mountain. The mud volcanoes of Turbako, near Cartagena, in Columbia, have been described by Humboldt. They consist of from twenty to thirty small cones, scarcely six yards high, with small orifices from which nitrogen gas is exhaled. Two mud volcanoes are found on the north point of the Celebes, lying on a slightly sloping ground. In a shallow depression is a lake of liquid mud, flecked with blue, red, and white, boiling furiously, and sending up bubbles in many places. Round the lake, upon the hard clay, are small springs and craters full of boiling mud. They renew themselves continually; first of all a small hole is seen, out of which radiating lines of foam and liquid mud are ejected, forming, as they cool, mounds with a central crater. The ground is very unsafe for some distance round, evidently liquid at a little depth below the surface, and yielding to pressure like thin ice. Wallace held his hand over one of the smaller streams, to feel if it was really as hot as it looked, and a little drop of mud spurting on to his finger scalded him like boiling water. At a little distance was a shallow plain of bare rock, as smooth and hot as the plate of an oven, obviously an old dried-up pool of hardened mud. For a hundred feet round, where ridges of white and red clay were seen, the ground was so hot that the hand could scarcely be held a few inches down one of the fissures. Strong sulphurous exhalations rose from every rift; and it is said that a few years ago a Frenchman visiting the spot ventured too near the liquid mud, and the crust giving way beneath his feet, fell into the fearful caldron below.

The mud volcanoes known as salinæ, or salinelles, because salts are extracted from their waters, are only found in districts where naphtha and carburetted hydrogen come to the surface, indicating the presence of considerable subterranean decomposition of organic substances, and especially the carbonization of plants. The salinæ have therefore an essentially different origin from mud volcanoes, but are often found in their neighbourhood. Lasaulx, who has made this subject a special study, considers that the mud springs, or salinelles, consist of the union of gaseous volcanic emanations, with water flowing through porous strata containing gypsum, rock-salt, lime, and other salts. The carbonic acid gas of the salinelles is formed of the same emanations, aided by the co-operation of strata above mentioned, while the eruptions of the mud volcanoes are owing to the upward crushing movements occasioned by the dislocation of the strata.

AN AVALANCHE.



WATERSPOUT OBSERVED IN THE MEDITERRANEAN.

CHAPTER VI.

THE ATMOSPHERE.

THE surface of the earth is surrounded on all sides by a gaseous atmosphere, consisting of twenty-one parts of oxygen and seventy-nine of nitrogen, with a slight admixture of carbonic acid, and a changing quantity of aqueous vapour. The density of the air decreases from below upward, until, owing to its increasing rarity, it escapes our observation altogether. On the level of the sea, in 45° of latitude, and with the barometer standing at 29·94 inches the density of the air is $\frac{1}{10517}$ that of quicksilver. Two miles above the sea level its density is only $\frac{3}{5}$ of what it was on the sea level; at a height of eight miles, only $\frac{1}{6}$; at twelve miles, only $\frac{1}{14}$; at sixteen miles, $\frac{1}{33}$; at twenty miles, $\frac{2}{1000}$; at thirty-two miles, $\frac{1}{1000}$; and at forty miles, only $\frac{1}{6000}$. As at the level of the sea the atmospheric pressure of a column of quicksilver 29·94 inches high is in equilibrium, therefore a column of air from the lowest to the highest strata is as heavy as a column of quicksilver of equal base, and 29·94 inches high; and the collective weight of the atmosphere is as great as that of an ocean of quicksilver covering the whole surface of the earth to 29·94 inches in height. This weight amounts to 5,500 billions of tons.

The air is not perfectly transparent; on the contrary, the sun's light passing vertically through the air loses one-fifth of its brightness; and when the sun is on the horizon, the light is only one-sixtieth of what it would be if there were no atmosphere. In the lower atmospheric strata the transparency is very variable. Saussure was the first to construct a diaphanometer to determine the degrees of transparency. Two white discs, six feet five inches in diameter, and having in the centre a black circle twenty-four inches wide on one disc, and only two inches on the other, were moved to a certain distance from the spectator, so as to make the smaller one disappear first. The light on both being as nearly as possible equal, it would naturally be expected that the larger black spot would disappear from sight at twelve times the distance of the former, supposing there were no absorption of light in the atmosphere. The experiment, however, shewed that the large black spot could not be seen so far away, but disappeared at 11·427 times the distance. Admitting this experiment as a sufficient test, it follows that the collective atmospheric absorption of light would amount to 0.307 the intensity of the original ray. Instruments constructed with greater accuracy, however, shew nothing more than the absorption which takes place in the lowest atmospheric strata.

Apart from the polar lights of the extreme north and south, the occasional development of the earth's own light is of great scientific interest, small as the part may be which it plays in the telluric organism. At present, great uncertainty prevails as to this faint, transient, periodic light of a body which is generally supposed to have been deprived of all light in long distant ages. Many and diverse may be the possible sources from which this development of the earth's light arises.

Beccaria seems to have been the first who called attention to the faint, diffused light of certain clouds seen on moonless nights, and at a distance from all artificial light. He writes of certain scattered clouds seen upon winter nights gathering into a compact mass, and then sending out a reddish light, strong enough to allow of reading a book printed in ordinary type. This curious cloud-light was generally seen after a fall of snow. We have noticed this phenomenon more than once, but not in winter; it seemed as though the clouds were composed of faintly phosphorescent vapours; but the diffused light was not sent out by all the cloud-mass visible at the same time, neither was it strong enough to read print by. Perhaps this diffused light is the same as that mentioned by Arago as guiding our footsteps in the cloudy nights of autumn and winter without the aid of moon, stars, or snow.

It is said that the phenomenon known as dry mist, and especially noticed in the years 1783 and 1831, has the property of sending out a faint light in the night-time. The many wonderful properties claimed for this dry mist excited general incredulity, but the fact of its existence was confirmed by distinguished physicists, and by evidence from Genoa, Berlin, and Siberia. Less is known as to the outward cause of the light than of the nature of the phenomenon itself; for, according to every report of the appearance and diffusion of the mist, it can scarcely be doubted that it has much in common with marsh smoke. The columns of smoke rising from the burning turf moors in Holland and north-west Germany are not broken up as they ascend, and dispersed by the wind in small particles, but move in masses, obscuring the sun, and sweeping across Europe and even the Atlantic Ocean, according to the direction and intensity of the atmospheric currents.

We may mention the theory of Laplace, which attributes the dry mist to a development of electric fluid; of Van Swinden, which refers it to volcanic smoke; and of Cotta, who explains it as metallic smoke, originating by the combination of great heat and electric currents, if only to shew what a problem is presented to the scientific world by the simple Frisian peasants who are accustomed to set fire to their moors every spring, that they may better cultivate their crops of buckwheat. Identical in origin with the marsh smoke is the greyish-yellow or reddish-yellow vapour which suffuses the whole horizon during the summer months in Spain and Switzerland, and makes the sky look of a leaden grey. This phenomenon is seen in Spain during the months of June, July, and August, and by the end of September no trace of it remains. If, however, the moor smoke extends as far as Spain, it is in a highly rarified form, so that it cannot be perceived at all except from a distance, when it clouds the strata of air through which it is diffused with a turbid red colour. And in Switzerland, where it is brought by the north and north-easterly winds, it is only perceptible at a great distance, when it covers the Alpine chains with a misty veil. Wilkomm compares it, not inaptly, to the Fata Morgana which flies before the steps of the traveller as he pursues it.

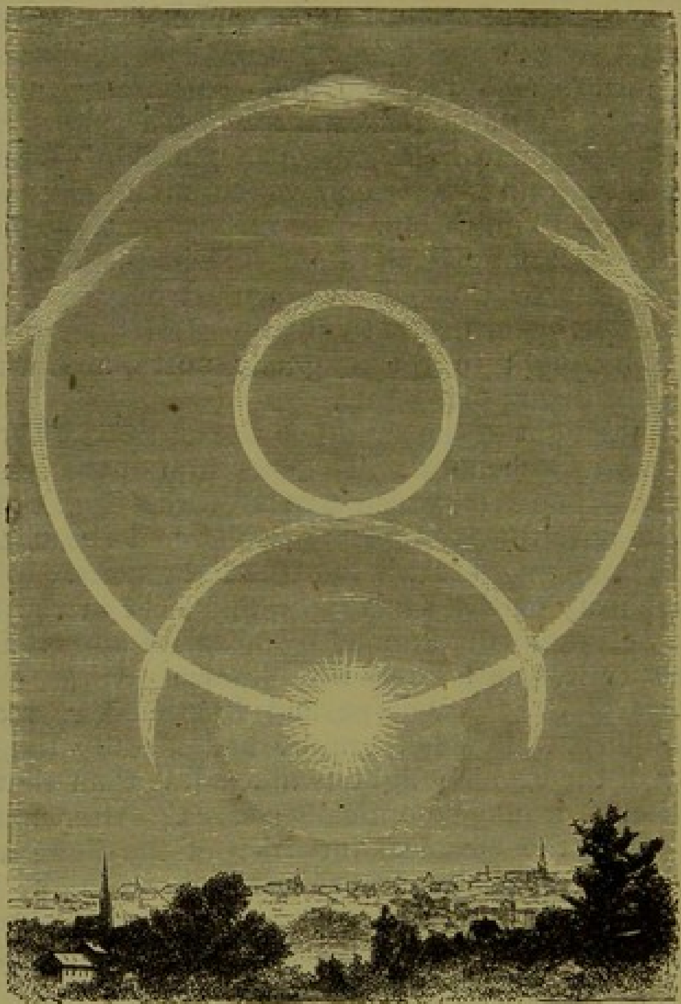
Although we have now learned the true nature of the dry mist, its intermittent diffused light is still unexplained. The clear light by which print was read at midnight on the 3rd of August, 1862, cannot be referred to the light of the moon, for it was then new moon, nor to the twilight, for that would imply a reflection of the sun's rays received upon particles of mist extending in masses far beyond the limits of the atmosphere—a supposition contrary to every observation. It remains, then, an open question to this day, whether the diffused light of certain clouds and vapours is of electric nature, or the result of phosphorescent illumination. We believe that the light emitted by isolated masses of cloud is not of such rare occurrence as is generally imagined, but that it is very often overlooked. Care must be taken, however, not to mistake this diffused light for magnetic processes of light development, such as are often seen by night in the magnetic north, and which are closely connected with the brilliant polar lights.

The action of the light of the sun upon the earth is of threefold nature—illuminating, heating, and chemical. The spectrum of the sun's light contains three different kinds of spectra, which partly overlie each other; toward the red end is the heat spectrum, toward the violet end the chemical spectrum, and in the centre, combining both, is the true light spectrum.

While the intensity of the sun's light and heat in the atmosphere has been more or less accurately determined by means of numerous investigations, the chemical intensity was until lately little known.

The researches of Roscoe, Thorpe, and Bunsen have rendered valuable service to this enquiry, while photography had already taught us that the chemical intensity of the evening light is much less than that of other parts of the day, even though it may be optically clearer. After many experiments, a definite measure for the chemical intensity of the light was obtained by noticing upon a paper specially prepared to absorb light the degrees of shading marked, and the time required by the process. It was found that the average chemical intensity of the collective light of one day is the same for hours equally distant from noon. The investigations of Roscoe and Thorpe, instituted at Lisbon in the autumn of 1867, and at Catania in December, 1870, shew that when the sun's altitude is under ten degrees, there is a total absorption of all the chemically active rays in the atmosphere, and that in equal altitudes the greatest chemical intensity is found when the atmospheric temperature is highest. We have therefore an annual period in the chemical intensity of heat, which is greatest in summer, and least in winter.

An opportunity occurred on the 22nd of December, 1870, of investigating the chemical intensity of light during an eclipse of the sun, and of determining the effect of the successive cloudings of the sun's disc upon the chemical intensity of light. During the famous eclipse of the 18th of August, 1868, Lieutenant Herschel had directed his attention to this subject, without, however, being able to obtain satisfactory results. In Catania, Roscoe and Thorpe observed that the chemical intensity of the light decreased exactly in proportion as the shining sickle of the sun grew less. The collective chemical intensity of light is made up of the chemical intensity of direct rays, and that of the rays of dispersed or diffused light. It was found that the decrease of the chemical intensity of dispersed light during the first period of the eclipse is rather greater than corresponds to the darkened part of the sun; while from that time to the total eclipse the decrease is rather less. Lieutenant Herschel had already observed this fact, which speaks decisively as to the accurate method of observation; the reason of the slight anomaly is that the



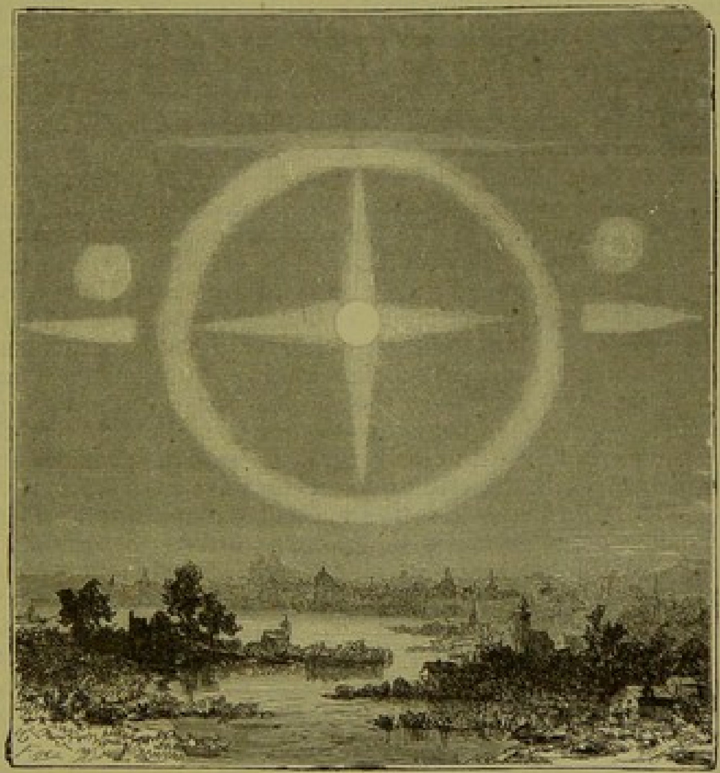
Mock Suns (Parhelia) observed at Leipsic, March, 1857.

moon holds back the light of the shining parts which are nearest the sun's edge.

Passing from the chemical action of light to its optical phenomena in the earth's atmosphere, we find ourselves confronted with appearances which, while they have been observed from the earliest ages, have either waited for the present day to receive a theoretic explanation, or are still to be interpreted by the light of future discoveries. Among these phenomena are the general daylight, the blue colour of the sky, the marvellous hues of sunset and sunrise, the tremulous flickering of the stars, the coloured rings round the sun and moon, and other similar appearances.

The common light of day is due to the imperfect transparency of the atmosphere; for the manifold reflection of light through and within our atmosphere creates that diffused light which illuminates also objects not exposed to the direct rays of the sun. From Tyndall's investigations, we know that an absolutely pure atmosphere, free from every particle of dust and smoke, would have the effect of an optically empty space. The smaller the number of suspended particles in the air, the less is the amount of daylight. And that is why upon lofty mountains the shadows are so much sharper and darker than in the plains and in places directly lighted by the sun.

The clear, cloudless sky is always blue; but the intensity of the blue colour is infinitely varied. The intensest blue is found at the zenith, and shades down towards the horizon to a pure white. Although at the present time there is a great lack of accurate measurements of the blue colour of the



Mock Moons (Paraselenæ) observed in Dresden.

sky, principally owing to the want of suitable instruments, it is proved beyond a doubt that the blue of the sky is much deeper and more intense in tropical than in non-tropical countries, more far inland than by the sea-coast, and above mountain tops than in the valleys. In Senaar, Bruce was often able to discern the planet Venus by daylight, owing to the great transparency and dark-blue of the sky. The darkness of the sky seen from great heights above the earth's surface has often been observed by Saussure to admit of the stars being distinctly seen in the daytime. The latter scientist constructed a cyanometer, marking with a mixture of good Prussian blue and Indian ink a scale of fifty-three degrees from white to black, and comparing the gradations of blue with that of the sky. In this manner the blue of the sky seen from the summit of Mont Blanc was 39°, and from heights of 16,000 to 18,000 feet in tropical America, 46°.

Tyndall has furnished the true theory of the blue colour of the sky and its manifold gradations. When experimenting upon the decomposition of vapours by means of light, it was necessary that the tube in which the vapours were confined should be freed as far as possible from every particle of dust. In comparatively pure air the particles of dust are not visible in diffused daylight, but it is enough to send a ray of sunshine or of electric light through the air to reveal the presence of an immense number of minute floating particles of dust. To separate these particles, the air used in the experiments was first passed through two tubes placed one behind the other, the first tube being filled with little pieces of glass which had been steeped in concentrated sulphuric acid; while the other contained chips of marble wetted with a strong solution of caustic potash. Although the air had been slowly passed through these tubes until it had given out all its moisture and carbonic acid, the experiment tube still shewed a number of particles which were vividly illuminated by the electric rays. It was not until the air had been passed over the flame of a spirit lamp into the drying apparatus that the particles were removed; they were burnt up, and in burning they betrayed their organic nature. When, after this, a spirit lamp was placed in a very intense ray, in the midst of which were seen numberless floating atoms of dust, black stripes were observed round the edge of the flame. To find out whether these dark stripes were of the nature of smoke, a red-hot iron was held under the ray. The dark masses rose upward from it as they did from the flame. A very intense flame of hydrogen was then turned on, and it produced the dark clouds in a much stronger development. The masses then were *not* smoke, indeed they had no actual existence of their own, and were simply negative phenomena; for the flame, as soon as it was put under the light, destroyed the organic particles, and the air freed from its impurities rose up, driving the lighted particles before it, and left in their place darkness, because, being then perfectly transparent, the ray as it passes through it is reflected from nothing, and completely invisible; while from right and left, was seen a light caused by reflection. The above experiments demonstrate the cause of the diffused daylight as shewn above. The same series of experiments, extended and modified, led to the discovery of the reason that the sky is blue. As the air was led too quickly through the flame into the experimenting tube, Tyndall was surprised to see a blue cloud rising from the smoke of the burnt organic particles. Further experiments shewed that the clouds which rose from the most diverse substances always assumed a blue colour. Now it is well known that the blue light waves are the shortest waves in the visible part of the sun's spectrum. When, therefore, a cloud begins to form, its smallest and first formed particles will reflect the blue waves; and as the cloud increases and the particles grow larger, larger light waves will be thrown back, until at last, at a certain size of the particles, white light is reflected, and the cloud is formed before the eyes of the spectator. The slow rising and passing away of invisible cloud germs is therefore, according to Tyndall, the cause of the blue colour of the sky,—an appearance which depends entirely upon the size of the drops or particles of which the cloud is made up. The watery vapours in the atmosphere, which help to make up the clouds, reflect blue when their watery envelope is most attenuated; and in proportion as the moisture of the air increases, the drops already formed increase in thickness, while at the same time others are formed of the smallest size, so that the blue passes gradually over into white. The results which Tyndall obtained by experiment correspond with those arrived at by Sorby, who started from the supposition that watery vapours in a state of absolute transparency would absorb more red rays and reflect more blue ones; and that the lower atmospheric strata, owing to the impurities they contain, would more strongly absorb the blue rays. The blue tints seen upon distant mountains, which principally produce the effects known as aerial perspective, are caused in part because those portions of the earth's surface which are not lighted by the direct rays of the sun owe their illumination principally to the blue rays of the sky.

The fact that the blue of the sky is to be ascribed to watery vapours, and the part played by the degree of moisture and size of the particles of vapour, explains in the most satisfactory manner the different intensities of blue as seen in various heights and positions on or above the earth's surface. For, the less moisture there is in the air, the purer and deeper is the blue of the sky, because in this case the particles of vapour are the smallest. Now the moisture of the air is least at the tropics, and gradually increases toward the poles; and it is less in inland places than along the coast; hence the splendid blue sky in the tropics and inland, in comparison to the sky along the coasts. As to the proportion of moisture to that of height above the sea level, it is now known that up to a certain height the moisture increases, then, after reaching its maximum, it decreases. The zone of atmospheric moisture is not found at equal height above the earth's surface, but generally is between 3,000 and 6,000 feet above the sea; beyond this point the moisture decreases quickly, the blue of the sky becomes more intense, and as at great heights the air is freer from dust, the sky appears of a darker hue.

Tyndall's experiments have shewn that the atmosphere, when perfectly pure, is transparent, and allows the ray of light to pass through it without becoming visible to the eye. If therefore the atmosphere were perfectly pure, it would be as a vacuum to the sun's rays, and immediately after sunset it would be as dark as midnight. Instead of this, the familiar phenomenon of dusk or twilight intervenes before sunrise and after sunset, as a connecting link between night and day.

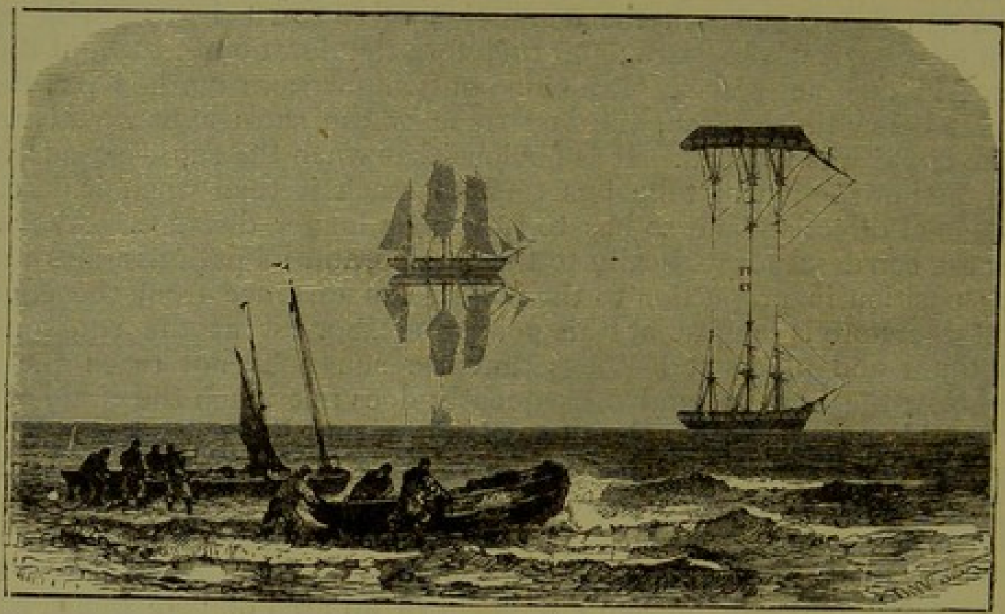
Astronomical twilight is not the same as the twilight recognised in every-day life: the latter ends when it is too dark in the house to see without artificial light; the former does not end until the last ray of light has disappeared from the western sky. Our ordinary twilight ends, as a rule, when the sun is 6 or 6$\frac{1}{2}$ degrees below the horizon, while the astronomical twilight was supposed to last till the sun is 18 degrees below. But from accurate observations made by Schmidt in Athens, the last trace of twilight vanishes when the sun is 15$\frac{9}{10}$ degrees below the horizon, and in similar observations made by Behrmann in equatorial latitudes, the end of the twilight coincided with the 15$\frac{6}{10}$ degrees of the centre of the sun's depression.

The sun does not reach the depression of 16 to 18 degrees with equal speed in every part of the earth; and therefore the duration of twilight differs, of course, in different places. If a circle of twilight were marked parallel to 18 degrees below the horizon, the last trace of the sun's light would vanish when the circle was reached. It is obvious that when the sun descends vertically to the horizon it will take less time to reach it than when it descends in a diagonal direction, and so has to traverse a longer distance. Above the equator the sun descends vertically to the horizon, and its path assumes a more slanting position in proportion to the increase of distance from the equator. Twilight therefore is longest at the poles, and shortest at the equator. In certain times and places it happens that the sun does not reach the 18th degree below the horizon, and consequently does not reach the circle of twilight. In this case there can be no real night, and days are divided by an uninterrupted twilight. This long twilight is met with on the 1st of June of every year in places below 50 degrees north latitude.

On closer examination of the phenomena of twilight, the same recurrent characteristics are more or less clearly perceived. Soon after sunset there appears exactly opposite the sun a segment of an arch of pale bluish colour, which gradually darkens to a leaden shade. This is the shadow of the earth seen in the atmosphere; it grows larger as the sun sinks lower, and the first stars are generally visible above its apparent centre near the zenith.

Turning from the phenomena of twilight, let us consider briefly those belonging to sunrise and sunset. The latter are seen to greatest advantage when the sky is blue, with only a few isolated clouds floating in the firmament. Tracts of glorious red and purple cover the western sky; but if the whiteness of the air shews the presence of watery vapours, a pale yellow light is spread across the sunset heaven. These atmospheric vapours are the cause of the colouring of sunset and sunrise. In a condition of absolute transparency the vapours absorb more red rays than those of any other colour. This is the case in the highest strata of the atmosphere only; but in the lower strata the transparency of the vapours is greatly dimmed, and as the result of this want of transparency the blue rays are absorbed, and the red transmitted. At sunset and sunrise the sun's rays have a distance of about 160 miles to travel through the atmosphere, at an average height of about 5,000 feet, in order to meet with a cloud at this height. During this long journey through strata of air filled partly with very dense and partly with opaque molecules, the blue rays are absorbed much more than the red, and the cloud appears more or less red. But as the sun rises above the horizon, a number of yellow rays are added to the red ones, so that the colour is changed into orange, and at last becomes perfectly white. The different colours can be shewn at the same time by clouds of different height and position; but in this case it will be necessary that the sun's light should not be hidden from the spectator by dense opaque masses of cloud. In a fine sunrise, therefore, there will be but few clouds in the eastern sky, along a line of more than eighty miles, and so with the western sky in a fine sunset. Since, then, in our localities the west winds are the most prevalent, and since as a rule they usher in dull weather, red clouds at sunrise announce a probability of rain, while a fine sunset, with few clouds in the west, foretells fair weather.

Among the most interesting atmospheric phenomena is the mirage, or Fata Morgana, seen from the midst of a sea of sand or water. Especially in the desert is the *sehrab*, as the Arabs call the mirage, an unwelcome sight. The traveller fancies that he sees in the distance blue lakes, overshadowed



MIRAGE AT SEA.

by tall, waving palm trees; but on his nearer approach the vision fades away. In the Nubian desert the phenomenon is seen more frequently in the north and eastern regions than in other parts of the desert. Burckhardt relates that during a whole day's journey he was encircled by mirage lakes on every side. Their colour was a deep, intense blue, and so vivid that it reflected the shadows of the mountains round the horizon with the greatest accuracy. This is the ordinary type of the Fata Morgana, but the phenomenon appears under other forms which are less frequently mentioned. When the sun's rays are reflected with great intensity from the sand, all objects on the desert plain are magnified, and appear considerably larger than they really are. A stunted shrub, with scarcely a trace of shadow beneath its parched and shrivelled branches, appears to the traveller as a noble tree, able to shelter him beneath its shade. Sandy mounds look like high and distant mountains, and in a few minutes the camels have reached them, and their true insignificance is revealed. D'Escayrac mentions another form of mirage. Near to the horizon a camel of great size is seen; the head touches the line of sight, and the creature itself is in an inverted position, with its four legs in the air. By degrees the size gradually lessens, dwindling every moment until at length it appears only as a black spot. The camel has then crossed the horizon, and regained its true size and position; scarcely visible at first, it becomes gradually larger as it approaches the spectator. It has been well known ever since the French expedition into Egypt, and the researches of Mange, that all these phenomena are caused by an extraordinary refraction of the rays of light in the over-heated strata of air near the ground. Travellers not familiar with the sight are easily deceived; but the camel, with its keen scent, is rarely mistaken. At times a real lake is mistaken for a play of the mirage, until the thirsty camel, scenting the water from afar, quickens his steps in its direction.

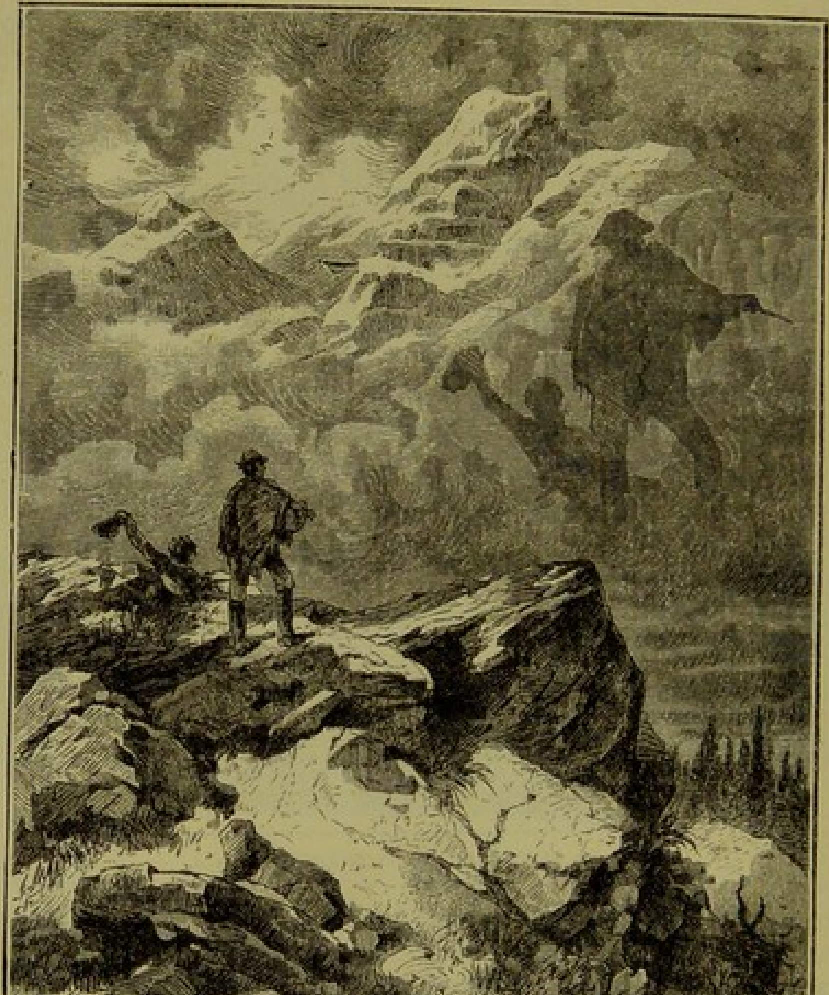
Beautiful and curious aerial mirages have been observed by Captain Scoresby, in his expedition in the Greenland waters. "One day in the year

LATERAL MIRAGE OF AN ASCENDING BALLOON.

1822," he writes, "I saw, clearly traced against the cloudless sky, the image of a ship upside down; the real vessel was not in sight, not having as yet appeared above the horizon. I had often seen similar phenomena, but the peculiarity of the present one was the extreme clearness of the image, in spite of the great distance of the ship which it represented. It was so sharply defined, that, as I examined it with my telescope, I could distinguish every sail and the peculiar build of the ship so distinctly as to be able to recognise it as my father's. We found out afterwards, upon comparing our ships' reckoning, that we were nearly thirty nautical miles apart at the time, the reflected ship being about seventeen miles beyond the horizon, and several miles beyond the range of vision."

Some interesting instances of this kind of optical illusion have been recorded by Vince. In good weather, the four highest towers of Dover Castle can be seen from Ramsgate, while the lower part of the building is hidden behind a hill. At about seven o'clock in the evening of the 6th of August, 1806, Vince saw, as he was looking toward the coast of Dover, not only the four towers, but every part of the castle, down to the ground on which it stands, and appearing to be between Ramsgate and the hill by which it is really hidden. Another day, having directed his telescope toward the open sea, he saw at the horizon a ship, above which was its perfect reflection, but inverted, so that the top of the mainmast rested upon the mainmast of the real ship.

The so-called spectre of the Brocken, and the phenomenon often seen by aëronauts, in which a magnified reflection of the balloon appears above or below them in a lateral position, belong to this class of optical illusions.



THE SPECTRE OF THE BROCKEN

TEMPERATURE OF THE EARTH'S SURFACE—ATMOSPHERIC TEMPERATURE.

The sun, our great source of light and heat, sends down his rays through the atmosphere; a small proportion of them being absorbed by the air through which they pass, while by far the greater number reach the earth, and communicate to it their store of heat. By this means the surface of the earth itself becomes a source of heat, and imparts it to the atmospheric strata resting upon it by diffusion and radiation. This is what we mean by atmospheric temperature, and register upon our thermometers. It is obvious that the more vertically the sun's rays fall upon the earth's surface, and the longer their action is continued, in other words, the longer the sun shines, the greater will be (*cæteris paribus*) the heat of the earth and of the lower atmosphere. Accordingly we find the heat greatest at the equator, and lessening gradually toward the poles. In our latitudes the sun rises relatively high in the heavens during summer, causing the day to last longer than the night, so that occasionally our thermometers register a temperature not much less than that of equatorial districts.

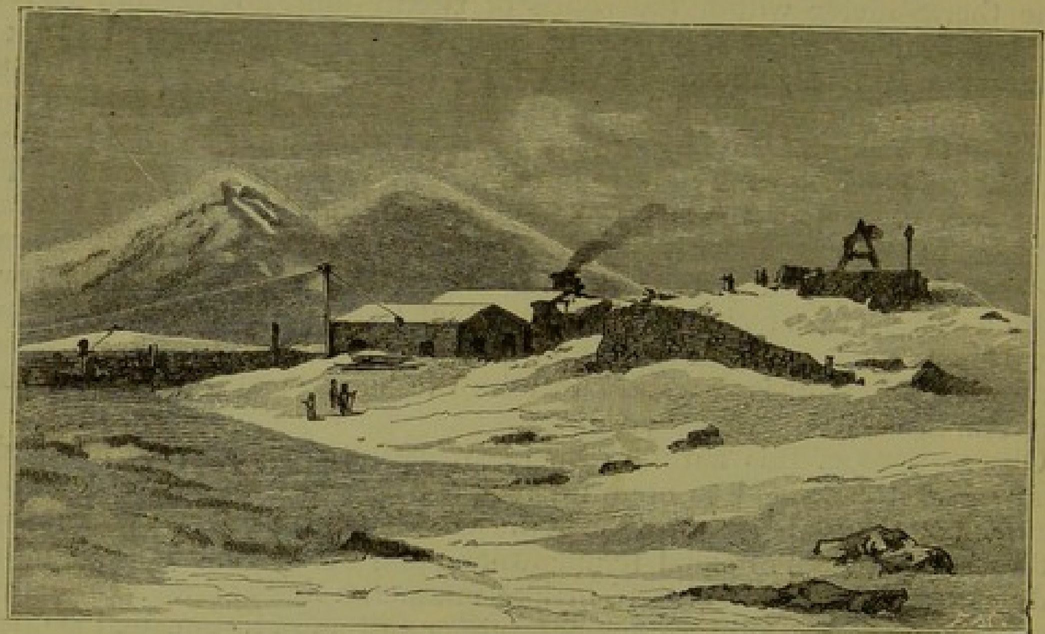
If the state of the thermometer is recorded day and night, from hour to hour, or better still, if a self-registering thermometer is used, we find that the coldest hour is that immediately before dawn. The temperature then begins to rise from hour to hour, and reaches its maximum at about two o'clock in the afternoon, after which it gradually decreases.

The average daily temperature is the average degree of heat recorded by the thermometer within the space of twenty-four hours; and can be ascertained with sufficient accuracy by reading off the thermometer at six in the morning, at noon, and at ten at night, adding up the number of the degrees, and dividing the total by three. The average monthly temperature is obtained in a similar way, by adding together the average daily temperatures, and dividing them by the number of the days of the month. The average yearly temperature is obtained by adding together the average monthly temperatures, and dividing the total by twelve. When the average daily, monthly, and yearly temperatures have been established in this way through a series of years, it will be found that they are not always of equal value, but are greater in one year and less in another. In order to obtain accurate reckonings, it is necessary to take the average of observation made during ten, fifteen, and twenty years.

Observations of this nature have been instituted in a great number of places; but if it is desired to obtain a record of the distribution of heat over the surface of the globe, it must be represented upon a chart, by drawing a line through all places of equal temperature upon the earth. These lines are called yearly isothermal lines. If, in like manner, a line is drawn through all places with an average summer temperature, a system of lines called isotheres is obtained ; while the lines connecting places of equal winter temperature are called isochimenes.

On examining a chart of yearly isothermal lines, it will be seen that the latter are parallel neither to the equator, nor to the degrees of latitude, nor to each. The same is true of the isotheres and isochimenes. The highest average yearly temperature is found north of the equator in the interior of Africa; the lowest in the district to the north of the American arctic island world, to the west of Greenland. The most irregular isotherms run through the North Atlantic Ocean and the interior of the continents. The reason of this irregularity is found in the general distribution of land and water, and in the marine and atmospheric currents. It has long been known that the nearness of the sea has an equalizing effect upon temperature, diminishing the cold of winter and the heat of summer. Great masses of land act in a contrary direction, increasing the cold of winter and the heat of summer. The reason of this opposite action of land and sea is easily seen. Water becomes warm very slowly, but loses its warmth with equal slowness. The contrary is the case with the mainland, which becomes hot and cold with equal rapidity. The temperature of the sea is therefore more uniform throughout the year than that of the land. When the land grows cold in winter, the sea becomes a source of heat, especially for the coast lands, where the influence of the higher sea temperature is more strongly felt. In summer, the land is much warmer than the water, and the sea exerts a cooling influence. Hence the difference between land climate and sea climate. The coast lands of the ocean and of islands washed by the sea are said to possess a sea climate. The interior of the continents exhibit all the characteristics of a land climate. Europe may be looked upon as a great Asiatic peninsula, pushed out westward into the Atlantic Ocean. We can understand then how it may be said of our whole hemisphere, that it enjoys the advantages of a sea climate. This is indeed the case, and because it is so the climate of Europe is the best in the whole world.

As a rule, the northern hemisphere is warmer than the southern; but in high latitudes the average yearly temperature of the southern hemisphere is higher than that of the corresponding latitudes in the northern half of the



METEOROLOGICAL OBSERVATORY AT PIC DU MIDI.

globe. The isothermal lines shew that, upon the whole, the land is warmer than the sea in low latitudes, while in high latitudes the sea is warmer than the land.

The isothermal lines, whether monthly or yearly, furnish data for the average proportions of heat, and form the groundwork of the study of periodic divergences in the distribution of heat. It has been found in this way, that all the important divergences from the regular or normal distribution of heat are not restricted to isolated small localities, but extend over large portions of the globe. Thus it never happens that in a country of small extent, such as Wurtemberg or Saxony, the winter is specially cold, or the summer unusually hot, without its being felt in the adjoining countries. Great cold and great heat extend regularly over large spaces of land. As a rule, the countries which exhibit the strongest contrasts of climate at the same time lie side by side in the direction from east to west. A more equal climate is therefore to be expected by any one travelling from north to south, and greater and more sudden changes of heat and cold by a traveller journeying from east to west. Europe and North America, for instance, exhibit, as a rule, sharp contrasts of climate and temperature. When we have an unusually hot, dry summer, it is generally cool and rainy in North America; and a very hard winter in North America generally coincides with a mild, open season among ourselves.

The temperature of the air decreases with increasing height. If the air were perfectly dry, the decrease of heat would amount to 1·8° Fahr. to about every hundred yards of height; but as the air always contains a certain quantity of aqueous vapours, the process of cooling is slower; slowest of all in the depth of winter, and most rapid in the hot, dry air of summer. At altitudes of four or six miles, the atmospheric temperature is nearly uniform and very low. Barral and Bixio, in their aerial voyage on the 27th of July, 1850, found at the height of 21,000 feet a temperature of 12·2° Fahr.; at 23,000 feet high, the terrible cold of nearly 39° below zero. While, then, the summer air in its lower strata is often found sultry and oppressive, the upper strata above us lie in a region of intense perpetual cold.

Atmospheric Pressure, and its Variations.

The pressure exerted by the air in consequence of its weight and elasticity is measured by the barometer. When the pressure increases, the quicksilver rises in the tube of the barometer, and falls when it decreases. The atmospheric pressure on the surface of the sea amounts to nearly 29·94 in.; but, like the density of the air, it decreases with increasing height. At the height of 6,000 yards, the pressure is only half as great as it is upon the sea level, so that any one standing at that height above the sea has half the weight of the atmosphere beneath his feet. Thirty-two miles above the sea level the pressure is so light that the barometer would only stand at ·04 inch; in other words, the air is so rarified that it becomes like that which fills a so-called vacuum, such as we are able to obtain by the aid of our best air-pumps. We see at once, therefore, that the atmospheric pressure varies according to the height of certain localities; and we are able to calculate backward the height of a place above the sea, if we know the state of the barometer at that place, and we also are able to tell by how much the pressure decreases for every yard of height. It is in this way that the barometer has done such good service in the measurement of altitudes. It has been carried over mountain and valley, to determine the rise and fall of extensive stretches of country. Without this barometric measurement of altitudes, even the vertical configuration of the land throughout a great part of Europe would be imperfectly known, a fact which is sufficient to shew of what importance the barometer has been to the study of physical geography.

The normal pressure of the barometer is not quite uniform, but exhibits variations in all parts of the world. If self-registering instruments are carefully observed, it will soon be found that these variations exhibit a certain regularity. As a rule, the barometer is lowest at about four o'clock in the morning. It then begins slowly to rise till towards half-past nine, falls again till toward four in the afternoon, and then begins to rise, reaching its maximum at about ten o'clock p.m., and falling through the night until four in the morning. These variations are known as the daily periods of atmospheric pressure; they are so slight as to pass unobserved, as a rule, being lost in the greater irregular changes of the weather. In Germany they only amount to about ·02 inch. In the tropics these variations of pressure are much more considerable, they amount to more than ·08, and occur with such regularity at certain hours of the day, that the barometer may almost be consulted like a clock, to tell the time.

There is also a yearly period of variation of atmospheric pressure. As a rule, the pressure is greatest in the winter in the interior of the continents, and least during the summer; while on the ocean the variations are much slighter and more irregular.

Lines drawn upon a map through all places of equal barometric pressure are called isobars. Their course is extremely complicated, and has as yet been far less thoroughly explored than that of the isothermal lines.

Movement of the Air—Wind Currents.

The air flows from the point of greatest pressure towards the slighter pressure, thereby producing what we understand as the wind. The greater the difference between the atmospheric pressure in two adjoining places on the earth's surface, the quicker is the movement of the atmospheric current, and the more strongly the wind blows. The shortest line drawn between two adjoining isobars shews the direction of the greatest difference of the atmospheric current there, or of what is known as the *gradient*. The nearer the isobars lie together, the greater is the difference in the atmospheric pressure, and the greater is the gradient. The slope of the gradient is expressed by the number of millimeters by which the atmospheric pressure decreases in the direction of the gradient for every equatorial degree. An atmospheric movement of about a yard in a second is just perceptible, ten yards a second sets the boughs of trees in motion, fifteen yards a second is a high wind, thirty yards is a storm, and forty a furious hurricane. The surface of the earth acts as a check to the movement of the air, especially when the land is broken and unequal. On the open ocean the wind currents meet with less resistance; but they sweep with absolute freedom through the higher strata of the air.

If we examine the distribution of winds over the earth's surface, we find near the equator a zone running round the globe, in which the winds are, comparatively speaking, at rest. This region is called the belt of calms. It owes its existence to the great heat of the earth, caused by the vertical rays of the sun, which in the hottest parts loosen and expand the air. If we picture to ourselves the atmosphere as consisting of strata concentric to the surface of the earth, these strata, supposing the atmosphere to be unequally heated from below, will extend unequally; this expansion will be greatest at the equator, and least at the poles; so that, owing to the elevation of surfaces of equal pressure in the equatorial districts, the strata receive a considerable inclination towards the poles; the equilibrium of the higher strata is now disturbed, the higher particles of air gravitate towards the poles, and flow as upper atmospheric currents towards the higher latitudes. Thus an influx of air takes place, and, as a necessary consequence, the atmospheric pressure is increased; this causes an out-flowing current of air from the higher towards the lower pressure; that is, the air streams near the earth's surface from the higher latitudes on both sides towards the equator. Owing to the rotation of the earth on its axis, these currents appear on the north side of the belt of calms as an uninterrupted north-east wind, and in the southern hemisphere as a south-east wind; the two arctic atmospheric currents are called trade-winds; their course is most unfettered across the ocean; and it will be remembered that it was the north-east trade-wind which terrified the companions of Columbus, because they thought it would render their return to their native land impossible; afterwards, indeed, the Spanish sailors learnt to do justice to the value of the trade-wind, and they bestowed on certain parts of the Pacific Ocean the name of the Ladies' Gulf, because a girl could guide the helm, and the crews of the galleons from Acapulco might sleep in peace while the changeless wind bore them in safety to the Philippines.

The belt of calms has, however, no fixed position on the earth's surface. Indicating, as it does, the zone of greatest heat, it follows the yearly course of the sun towards the north and towards the south. When the sun in its yearly course travels northward to the equator, and creates our summer, the belt of calms advances somewhat towards the north; but when, in the time of our winter, the sun descends below the equator, the belt of calms moves with it towards the south. In the Atlantic Ocean the belt of calms is not found on both sides of the equator, but to the north of it, between the eighth and third degrees of latitude. Even in the winter the belt of calms in the Atlantic remains rather to the north of the equator; the reason of this is found in the position of the continents, and especially of the extension of the northern part of Africa. In the Pacific Ocean, which is only broken by small islands lying far apart, the belt of calms extends more on both sides of the equator.

The upper currents of air flowing from the equator towards the poles is called the return trade-wind. Above the equator itself this return trade-wind is extremely high, far above the highest peak of the Andes; it sinks gradually northward and southward toward the earth's surface, coming in contact, for instance, on the Island of Teneriffe, with the summit of the Peak de Teyde, 12,000 feet high. A visible proof of the existence of the return trade-winds of the upper air was given on the 20th of January, 1835, by the volcano of Coseguina, when in a terrible eruption it hurled up masses of ashes to such a height that they reached the higher returning trade-wind, and were carried by it, in a direction diametrically opposite to that of the lower trade-wind, as far as Jamaica.

If the earth were a sphere entirely covered by water, and exposed equally in every part to the sun's rays, the trade-winds would set in everywhere with equal regularity; but the surface of the earth consists of land and water, and we know by experience that while the trade-winds blow with the greatest regularity across the great oceanic plains, they are greatly hindered by the masses of the mainland. In certain circumstances, indeed, the great continental masses are able to completely throw back the trade-winds, a phenomenon we see exhibited on a large scale in the monsoons of southern Asia; for we find in the Indian Ocean the south-east trade-wind blowing southward from the equator in the summer, as in winter; but to the north of the equator we find throughout the summer months a constant south-west wind, the south-west monsoon. This monsoon is caused by the heated rarified air of the immense plateau of Central Asia, which draws up the moist air of the Indian Ocean. When the sun travels southward in winter, the ordinary north-east trade-wind appears again, under the name of the north-east monsoon, but is changed by the heated masses of air rising from Australia to a north-west wind. At the time of the south-west monsoon, from April to October, the western coast of India is almost unapproachable for sailing ships, while during the north-east monsoon (October to April) the narrow, sandy, eastern shore allows no traffic by sea within its few harbours.

What the monsoon is on a large scale, the land and sea winds are in miniature. While the sun warms sea and land alike, the latter, all other things being equal, assumes a higher temperature much more quickly than the fluid surface of the sea. The heated air expands, and the cooler air flows in from the colder surface of the sea. This is the reason of the daily sea breezes which reach their greatest intensity at the same hour that the land attains its highest temperature, namely, between two and three o'clock in the afternoon. But when the land and water cool, as the sun sinks below the horizon, the land loses its heat as rapidly as it gained it; its temperature sinks quickly below that of the sea; and the same influence of the equalizing atmospheric currents which caused the sea breezes by day now creates a land breeze which continues until after sunrise. The intensity and regularity of the sea breezes are greatest where the greatest difference exists between the heat of the land and sea, and where the degree of heat is most uniform; that is, in tropical regions. The configuration of the coast exerts also a great modifying influence upon the play of land and sea breezes. In long, projecting promontories, the land breeze isslight, while the sea breezes are gentlest in deep, sheltered bays. In the promontories which are situated in the north-eastern and southern parts of Jamaica, the land winds are so rare, that in former times there was a superstition prevalent among sailors, that they were held back by demons. In Dampier's treatise upon winds, we find it recorded that several expeditions were sent out to Cape Pedro to meet and fight the supposed demons. In the same treatise it is said that in the Bay of Campeche, between Cape St. Martin and Conducado, the land breezes are very strong.

It is clear from what has been already said, that winds blowing from higher latitudes do not present the same regularity which characterises the winds of tropical regions. Dependent upon the distribution of sea and land, and the unequal proportions of heat and radiation, affected by powerful ocean currents, the characteristics of the winds of the northern temperate zone present local and temporary irregularities which are often extremely perplexing. Geographical meteorology is deeply indebted to the researches of Hann and Wojeikoff upon this subject. They have shewn that in the transition from winter to summer a great change takes place in the frequency of the different directions of the wind, and especially in the temperature they possess. This change is based upon the alternation of the difference of temperature between sea and land. In winter, the continents of the northern parts of Europe and Asia form cold centres, from which issue cold currents of air on the western sides as north-east winds, and on the eastern sides as north-west winds. But there is a great difference in their frequency on the east and west sides. Far along the western coast the flow of the warm equatorial current makes itself felt, while the cold arctic current flows down the eastern side, and necessitates a sharply defined contrast in the temperature of the western and eastern sides of the same continent.

In summer, on the other hand, the interior of the continents become centres of heat, so that the temperature along the same parallel of latitude rises toward the centre of the mainland, and causes a diminution of atmospheric pressure over the continental plains. These barometric minima form points of attraction for the colder air of the surrounding seas, and a general tendency of atmospheric currents from the sea to the land is produced. The sea winds are now cold winds, and the land winds from the interior of the continents are warm winds.

In Europe, where the sea breezes from the south-west prevail throughout the winter, the change in summer is less important. The wind takes a more northerly direction, and the climatic effect is the opposite of what occurs in winter, namely, a slight depression of the central temperature.

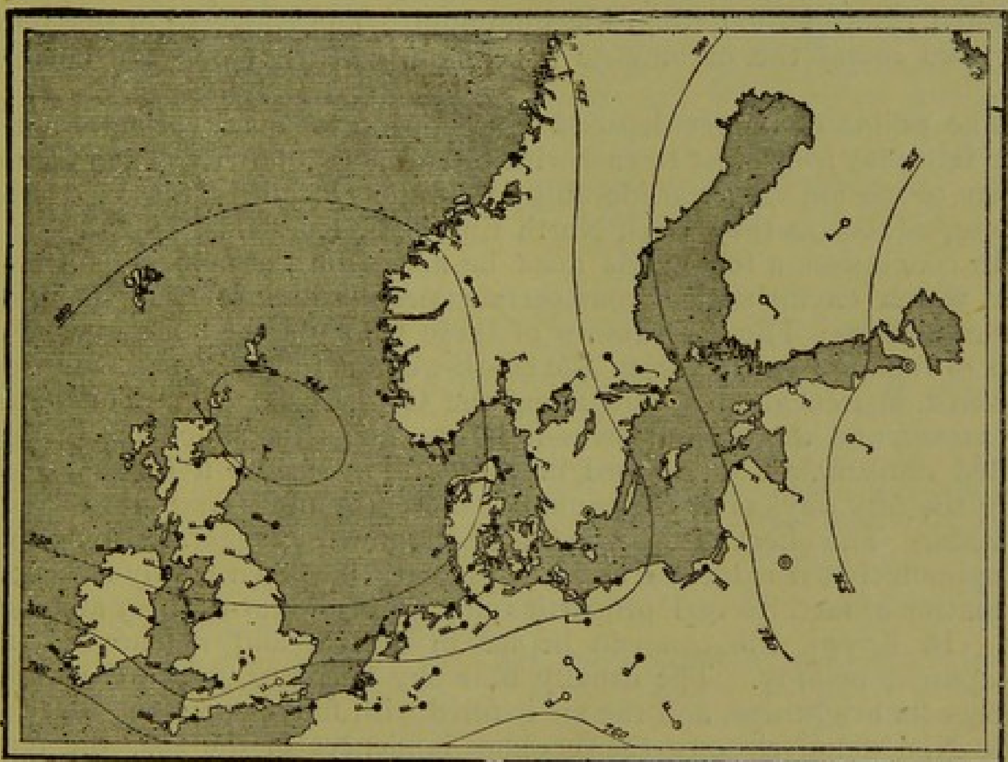
In eastern Asia, where, during the winter, the dry, cold land wind from the north-west prevails, a marked change of wind characteristics is experienced as the season changes to summer, and the cool wet sea breezes set in from the east, south-east, and south. The climatic effect produced is a lowering of temperature; and as a still greater depression had been caused in winter

MAMMOTH CAVE IN KENTUCKY.

by the presence of the arctic current, the extreme cold of the eastern side of the old continent is fully explained.

In eastern America the change is not so radical, and that for two reasons —first, because the stretch of land surfaces is of much smaller extent, and is moreover broken and intersected by large sheets of fresh water in the north, and secondly, by the presence of the great Mexican Gulf in the south. The prevailing course of the wind, which even in winter was more westerly than northerly, becomes now south-westerly, the east and south winds from the Atlantic Ocean being of comparatively rare occurrence.

If the direction of the wind is examined, with respect to the course of the isobars, it is found, as we have already stated, that the wind rushes from the point of highest pressure to the lowest, and that, in consequence of the earth's rotation, the air of these currents deviates in our hemisphere to the right, and



ISOBARS AND WINDS IN N.W. EUROPE, 29TH AUG., 1877.

in the southern hemisphere to the left. This, in a few words, is the famous law of the winds as expounded by Buys and Ballot—the corner-stone of modern meteorology. With reference to the isobars, the law may be expressed as follows:—the wind blows nearly in the same course as the isobar, having the place of the barometric minimum on the left; it blows more strongly in proportion as the isobars lie nearer together. According to this law, which is borne out by the evidence of fact, it is obvious that the wind must blow in a circular course round the barometric minimum, and in a direction contrary to that of the movement of the hands on a clock face. The wind runs round the place of the barometric minimum against the clock. This will be clearly seen by the accompanying chart, which shews the state of the atmosphere at eight o'clock in the morning of the 29th of August, 1877. The barometric minimum is seen between Scotland and Norway, but the wind is not violent there, because the isobars lie far apart. Examining, then, the course of the isobars of 29·9 and 30·4 inches, it is seen that their curve is on the whole contrary to that of the isobars encircling the barometric minimum. Now as the wind follows near the course of the isobars, and has always a higher barometric pressure on the right than on the left, it is clear that at the place of highest atmospheric pressure, in other words, at the barometric maximum, the wind runs with the clock. The course of the wind between the isobars of 29·9 and 30·4 inches, agrees with this. The points of highest and lowest atmospheric pressure exert an equal influence upon the current of wind, each turning it aside, but in a contrary direction. It has been already stated, more than once, that the wind follows the course of the isobars; but upon closer examination we find that the air is rarified above the barometric minima, causing as it were an absorption and an influx of the adjoining lower atmospheric strata. This produces a deviation of the general atmospheric current, causing the wind to swerve slightly from the course of the isobar towards the barometric minimum. The converse of this influence is exerted round the barometric maximum, where an outward curve takes place.

The points of lowest depression are by no means invariable, but move in our latitudes from west to east with tolerable regularity. Their course and rapidity of motion vary considerably in different localities, always decreasing, however, as soon as they reach North Europe or Russia.

In conclusion, a few words must be added on the subject of some local winds which excite notice from certain peculiarities of heat, dryness, and electric tension. The best known of these winds is the hot dry wind of the desert of Sahara, blowing from the south-west in Lower Egypt, and from the north-east in Senegambia, and along the Gold Coast. The Turks call this wind *samiel*, and among ourselves it is known as the simoom. In Egypt it is called *chamsin*, a Coptic word meaning fifty, because it blows principally during the fifty days after the equinox: in Senegambia, finally, it is known as *harmattan*. The effect of this wind has been much exaggerated by travellers. The opinion that it is mortal, and causes death, has been boldly stated; while, as a matter of fact, its real properties are simply great dryness and extreme heat. In Egypt, the chamsin begins in March, and reaches its highest development in May. The usually blue sky becomes grey and cloudy, the sun loses its brightness, and the air is filled with fine, penetrating dust. Even in the Nile delta, close to the cooling influences of the sea, the temperature rises sometimes, from the effects of this wind, with startling suddenness to 77° Fahr., while the moisture of the air is lessened to 12 or 15 per cent. Burckhardt once saw the thermometer at Esneh rise to 124 in the shade during the prevalence of this wind. The simoom generally blows in gusts; according to the Arab saying, "it leaps, and gallops, and makes hollows in the sand." The current rising in a slanting direction sweeps away the sand, lifts it in masses from the ground, and lets it fall back in cloudy sand showers.

The Arabs and the Bedouins familiar with the desert recognise many trustworthy signs which prelude and foretell the arrival of the simoom. Among these signs is a dark-red sunset on the evening before; the sun looking like an immense, sharply defined yellow globe floating in the red glow; and the appearance after sunset of a singular dim vapour high in the air, and known as the African high mist, through which the stars shine with a faint gleam. If these two signs are combined, a simoom may be expected with certainty for the following day. The wind begins at sunrise; generally speaking, with a clear sky; it does not blow very violently at first, but the curious thing about it, and that which strikes a foreigner most is that the wind itself is not cool, but lukewarm.

Every hour brings an increase of heat and violence, sometimes at the rate of four degrees in a quarter of an hour, so that by mid-day the warm wind is actually hot. It is then high time for Europeans to take shelter within their houses, and wait the end of the crisis behind closed doors and shutters, especially as the wind brings with it quantities of fine desert sand, which penetrates everywhere, actually entering into the furniture, instead of settling upon it.

The sky is now of a leaden grey, through which the sun appears as a large pale circle. At times, solitary rays, dull and lifeless in tint, break through the veil, hover for awhile in the air, and are lost again in the universal grey.

Out of doors, meanwhile, the temperature rises to 104° Fahr., and that not upon thermometers directly exposed to the wind, for on the windward side the readings are often as high as 122°. Eveling, who wished to assure himself by personal observation of the characteristics of the simoom, drove out one day when the wind was blowing, and leaving the town, took the direction of the desert. "As long as we were sheltered by the rows of houses," he writes, "the air seemed only oppressively sultry; but when, at a turn of the road, we reached the open, a hot wind met us face to face, like the suffocating steams of a vapour bath. The horses snorted, and bent down instinctively toward the earth, and some laden camels which were passing by did the same. Their drivers had carefully veiled their faces and covered their heads with blue cotton cloths. The desert itself, usually so light and bright, stretched out before us like a boundless ocean of dusky yellow. In the background rose the Mokkatam mountain range, generally a blaze of colour, now like a wall of shadow. We turned back, for we felt we had seen enough." The chamsin never lasts for more than twelve hours, always ceasing at sunset, and sometimes not beginning till noon. After a day of this wind, the full moon sometimes appears intensely bright, surrounded by a circle of light, which gradually spreads over half the sky; a splendid sight, and such as is never witnessed in our climates. At night the air cools down by at least twenty degrees, and on the next day everything is in its normal state.

Such, briefly told, are the phenomena of the simoom at Cairo; especially in the narrow streets of the Arab quarter, little is felt of it besides the heat and the dust, and the natives do not allow it to interrupt their ordinary avocations.

Of course the case is wholly different when the simoom breaks forth in all its violence, and its phenomena are exhibited in their highest form. These stormy days are fortunately rare, but they are very terrible. The 30th of April, 1875, will not soon be forgotten. The morning foretold nothing unusual, and the great storm fell upon us unawares. The signs mentioned above had not occurred, shewing that they are by no means a necessary part of the disturbance. The air, which had been calm and cloudless, darkened after noon suddenly, and in a few minutes a violent storm broke over Cairo. Soon afterwards the darkness was replaced by an unnatural sulphurous yellow glare, which increased every moment in intensity, and became at last so violent as to be extremely painful to the eyes. At three o'clock the wind raged like a hurricane let loose.

Our house, which stood alone and on high ground, rocked to its foundations; but in saying this, it is to be remembered that in the East all the houses are built, according to our German notions, very insecurely, having no cellars underground. The windows rattled until it seemed as if every pane must be shattered, and the tumult outside was indescribable. The high date palms bowed till their feathery crowns almost touched the earth, and the wooden verandahs on the flat roofs were torn up and scattered about like chaff. Meanwhile the spectral sulphurous yellow was reflected from all around; even the faces seemed to belong to men stricken with the jaundice. Of course this only refers to Europeans—the brown and black faces of the natives looked just the same as ever.

The sun shone dim and colourless as the moon, which was the more singular, because I had always read in descriptions of the simoom, that it appeared as a dark-red burning disc, an appearance which I was told had never been observed in Cairo, though it may have been seen in Upper Egypt or in the desert. There was no thunder and lightning, and yet the whole air was charged with electricity, shining sparks seeming to fall in isolated drops through the air. It is indeed well known that the simoom is often accompanied by electric phenomena. Strangely enough, it was not particularly hot; the thermometer never rising above 95° Fahr. It is proved that the March of that year had been colder than the oldest inhabitants of Cairo could remember.

Towards five o'clock the hurricane suddenly ceased; so suddenly that in ten minutes all was calm. Outside the town the wind had done terrific damage. The great acacias and sycamores planted along the dike leading to the pyramids of Gizeh were uprooted; the dike itself was undermined and thrown down in several places; happily the Nile had long since retreated into its original bed, or we should have had to deplore much greater devastations. The villages at the base of the pyramids had also suffered severely, and several of the fellahs' houses had been literally swept away. Upon the pyramids themselves the hurricane had left no shadow of a trace; in their long existence of 5,000 years, they must have passed through many similar catastrophes. At any rate, the 30th of April, 1875, was one of the most disastrous days which had occurred within the memory of living men at Cario.

We have hitherto spoken only of simooms as violent winds, but there may be days of simoom without wind, such as occurred many times in the year 1876.

As far as I was able to learn, no premonitory signs are known to usher in these windless simooms. The sun rises bright and clear, and the temperature retains its normal condition. In a few hours the sky is covered, not with clouds, but with a pale, semi-transparent veil of yellow, which does not completely hide the sun, but reflects its rays so that every object appears in a kind of twilight, casting only a faint shadow, as if seen during an eclipse of the sun. When the air is perfectly still, the temperature rises very quickly, sometimes as much as from 54.5 to 99.5 and 110 F. in an hour; but the heat is neither dry nor oppressive. With light clothing and rest it is possible to be borne without discomfort, and as it only lasts from six to eight hours it does not penetrate much within the houses.

The desert at these times presents a most interesting spectacle, stretching out before the eyes in every gradation of colour from the palest yellow to the darkest brown; thousands of vultures circle above the sands, and the laden camels move on in long files, like dark shadows. Suddenly a slight eddy rises in the sand; scarcely perceptible at first, it increases with every second, and in a few minutes rises as a gigantic column of sand, and speeds along the desert as a cloud pillar.

Sometimes, when of great height, it breaks asunder in the midst, and the upper part flies through the air like a balloon, and is carried on for miles, as a dark-brown cloud of sand. This is a phenomenon often seen upon such days, and it is not dangerous, as it is very easy to get out of the way of the whirling pillars. They often travel in couples, and sometimes in groups, when they are generally of smaller size; and in their strange approach they lend an air of unusual life and movement to the general dead monotony of the desert. At night the sky is again veiled, and round the horizon appears a broad band of violet, broken in the west by stripes of fiery red; a magnificent glory of colour which would delight the landscape painter, although critics who had never seen such skies would doubtless pronounce their colours reproduced on canvas to be exaggerated and unnatural.

After the 15th of May the simoom is not encountered; the wind from the desert is cool and refreshing; indeed, the desert wind in itself is never sultry or oppressive.

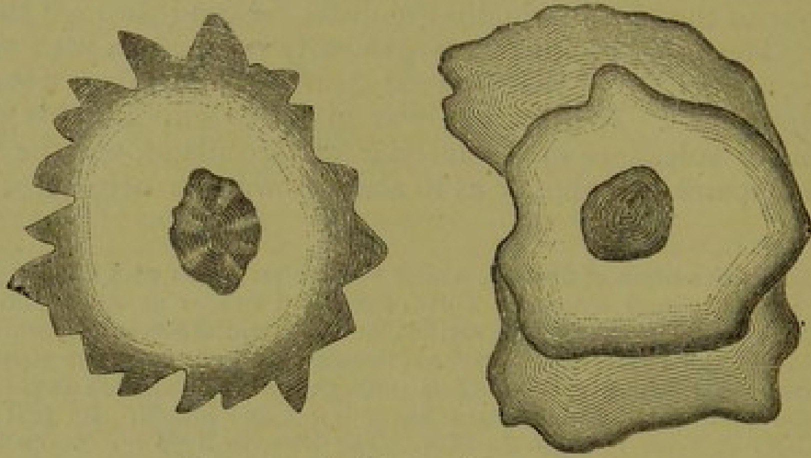
The story that caravans are brought to a standstill by the force of the simoom, and that the camels bury their heads in the sand to escape from death, is an exaggeration. As long as the traveller can see the sun or any object upon the horizon, the march is not interrupted; on the contrary, the thirst of the camels and the dried-up water bottles urge them to hasten at full speed toward the nearest well, which may only too probably be dried up by the parching heat of a simoom lasting two or three days. During the prevalence of this wind the whole atmosphere seems to be on fire; dust and sand are flying high into the air, in clouds of red, blue, or yellow, according to the ground over which the wind passes. Yellow is, however, the prevailing colour, and a good idea of the general effect may be gained by looking through a piece of pale yellow glass. The harmattan is attended with the same phenomena. The grass dies at once at its breath, the trees shed their leaves, and the rivers sink in their beds. A thick smoke-like vapour covers the sky, the sun shining through with a faint red light. The harmattan, however, is by no means an unhealthy wind; indeed, the Europeans rejoice at its approach, because it is a guarantee against the frequent attacks of pestilential fever.

The hot south wind known in Italy and Sicily as the *sirocco* is by some writers considered to be a genuine desert wind; Dove, however, pronounces it to be of West Indian origin. The *föhn* is a continuation or development of the sirocco, sometimes crossing the Alps, and rushing down upon the Swiss valleys. It is first heard among the mountain peaks, roaring high overhead; descending in gusty squalls, it hollows out deep chasms in the waters of the lake of Lucerne, and sweeps through the streets of Glarus and Altorf. The fires are extinguished in every house, for bitter experience has taught that the föhn permits no quenching of a conflagration. The Swiss geologists and meteorologists, seeing vegetation die and men suffer at the approach of the föhn, supposed that they saw an evidence in these effects, and in the dryness which causes them, of the desert origin of the storm wind. But Tyndal and others agree with Dove, that the dryness brought by the föhn into the valleys of Switzerland is no sign of its having passed over the Sahara; they contend that on the heights it is a cool wind, and only becomes warm by its condensation as it swoops down upon the valleys. And, as a matter of fact, the föhn, which appears in the east of Switzerland as a hot wind, melting snow and ice, is wet and cold in the west, and buries sometimes the mountain passes under loads of snow. The hot air of Sahara never reaches Europe at all, but wanders towards the north of Asia, causing, perhaps, there a gradual depression of the rivers and streams. Africa works with destructive effect upon Asia, but not upon Europe. The arctic regions furnish us with valuable evidence in support of Dove's theory; for the west side of Greenland has its föhn wind, which, blowing from the east and south-east, from the highlands of the interior covered with perpetual ice, yet brings with it great dryness and heat; melting the snow in the lowlands, but not creating any running streams. The storm begins there upon the mountain heights, where the snow is seen whirling about in the air; gradually the gusts descend through the fiords into the valleys. The south-east wind is generally ushered in with slight squalls of wind, snow, and rain; but the sky soon clears, and the rain is not considerable while the wind lasts. An attempt was made to explain this phenomenon by the action of volcanoes in the interior of Greenland, but the true cause is the warmth imparted to the air as it sinks down the heights of the central plateau.

The mistral, in the south of France, which sometimes rages with disastrous effect in the valley of the Rhone, comes from the north-west, and rushes in winter and spring like an avalanche from the heights toward the rarified atmospheric strata of the warm coast lands. In summer and autumn the terral blows from the central plateau of the Spanish peninsula in sudden stormy gusts. The leveche differs from the terral inasmuch as it blows from the south-east to the south-west, and only reaches a few miles inland. Its real district is the coast of the Cabo de Gata to Cuba de Nas. The leveche does not make its appearance suddenly. It is seen approaching on the southern horizon in the form of bands of cloud, changing from pale yellow to dark brown, and gradually advancing from east to west. Not a breath of air is felt, and the sea is as smooth as glass. When the wind reaches the coast, it does not strike it at once, but puts forth its strength in a succession of gusts of hot dry air, bringing with it clouds of dust and sand. Men and cattle droop at its breath, even the strongest natives feel violent headache and heaviness like lead in their limbs. The sand penetrates into every crevice, and covers the clothing with a number of small spots. Leaves of trees and grasses shrivel up at once, and fall to the ground in a day or two. In August, 1876, several square miles of vine plantations in the Sierra di Contraviesa, about eight miles from the coast, and more than 2,000 feet above the sea, were utterly destroyed a few weeks before the vintage. The leveche had come from the coast near Adra, climbed the Sierras, and attacked the vineyards with such capricious irregularity, that it was impossible to see why one had been destroyed and another spared. When the wind ceased, the vines looked as if boiling water had been poured over them. The whole phenomenon is confined to the lower strata of the air, as can be seen by the sharply defined upper outline of the dust. It is seldom seen in heights greater than from 300 to 400 yards.

THE MOISTURE OF THE ATMOSPHERE.

The atmosphere always and everywhere contains water in the form of invisible vapour, and in very variable quantity. The vapours are communicated to the air by the incessant processes of the evaporation of the masses of the water of our globe. Water condenses at every temperature; the rapidity of the condensation depending upon the increasing warmth, and the amount of watery vapour already contained in the air. The air, whatever may be its temperature, can only absorb a definite quantity of vapour, which it holds within it as invisible gas; and when this definite quantity has been absorbed, the air is said to be saturated. The process of evaporation, and of transforming water into invisible vapour, requires heat, and this heat has to be withdrawn from the water and its surroundings, thereby causing the cooling-down process of evaporation. The watery vapours form a kind of atmosphere within the atmosphere, and take part in its movement: they form also a circle of vapour which protects, like a shade, the strata of the earth's surface from the effects of too rapid radiation of heat. If it were possible to free the atmosphere above our own country from all the vapours it contains, a single summer night would be enough to destroy every plant which could not endure a temperature at freezing point. The small quantity of vapours in the air of the desert causes the extreme cold of the night there. In localities where at noon the atmosphere is heated like an oven, the nightly temperature sinks at times below freezing point. Europeans and natives alike suffer from the sudden changes, and Bruce records that upon one occasion he lost all his camels.

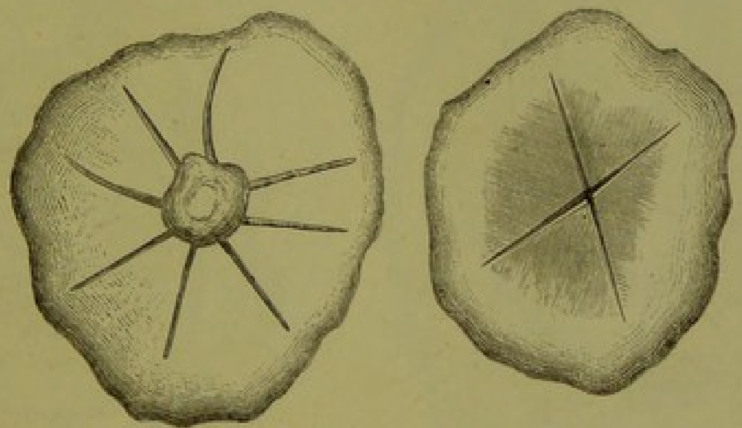


SECTIONS OF ICE CRYSTALS (REDUCED SIZE)

When the atmosphere is nearly saturated, the air is moist, and dry when but little vapour has been absorbed. These terms are only relative, and in themselves give no definite guide as to the amount of moisture contained in the air. In a temperature of 76° F. the air can contain ten drachms of moisture in every cubic yard, and if in a given case its real contents are seven drachms, it has not nearly reached the point of saturation, and appears dry. A mass of air with a temperature of 50° F. can hold five drachms of watery vapour for every cubic yard; and if in that case it has absorbed four drachms, it will appear very moist, although as a point of fact it contains far less vapour than in the former case. The actual amount of vapour contained in the air is termed its *absolute* moisture, and the proportion of this amount to the vapour which could be absorbed at the existing temperature is termed its *relative* moisture. The absolute moisture of the air is much greater in summer than in winter; but, owing to the higher temperature, the air in summer is on an average farther from its point of saturation than in winter; in other words, the relative moisture is greater in winter than in summer Analogous to this yearly period, there is a daily period of atmospheric moisture. In the interiors of continents, the quantity of atmospheric vapour is least at sunrise in summer, increasing toward nine in the morning. It sinks toward four in the afternoon, rises again till nine in the evening, and then decreases through the night until sunrise. The amount of vapour in tropical coast lands follows the same course, but the coasts of our temperate zones have but one daily wave of vapour, which is least at sunrise, and greatest at two in the afternoon. In the winter season the course is similar in its changes, but the difference between the morning and afternoon is much less.

Waters of the Atmosphere: Rain, Cloud, Hail, and Snow.

When a mass of air containing watery vapours cools down, the relative moisture increases, and if the cooling process continues, a point is reached at which the air has absorbed all the moisture it can hold at such a low degree of heat. Any further sinking of the temperature must be accompanied by a rejection of the moisture in excess of the point of saturation. The vapour is then forced to change its gaseous form, under which it was hidden in the air, for that of microscopic watery molecules, or what is commonly termed mist or fog. This condensation of vapour into fog is a phenomenon of every-day



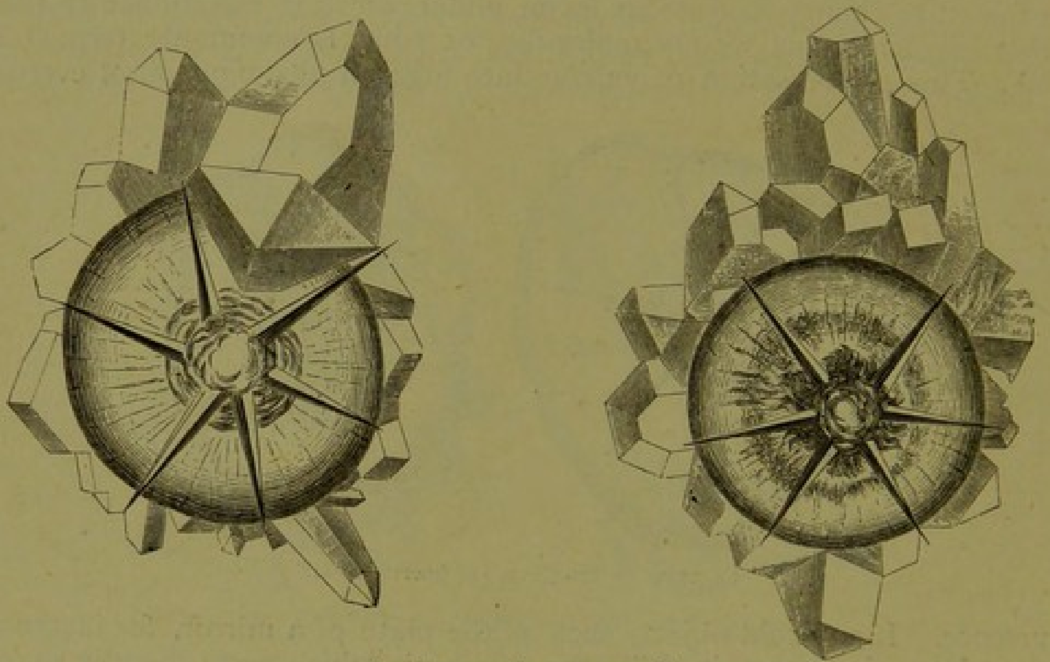
Sections of Ice Crystals (natural size).

occurrence. If any cold object, such as the plate of a mirror, for instance, is brought into a hot room, it chills the moist air which rests directly upon its surface to such a degree that the air can no longer contain the vapour within it, but lets some fall upon the glass. The strata of air cooled so that they exhale the first outpourings of moisture in this form are said to be cooled down to the dew point.

When a cold stream of air suddenly penetrates warmer and moister strata, it frequently lowers the temperature below dew point; and the vapours congregate together in the form of microscopic molecules of watery mist, which, when they float above us, we recognise as clouds. Cloud and mist are therefore essentially the same. That which, seen from the valley, appears to the spectator as a cloud upon the mountain peak, assumes to the spectator on the mountain the form of mist.

The formation of mist directly above the surface of the earth is easily explained; for when the waters of seas or lakes, or the moist ground, are warmer than the damp air resting upon them, the latter cannot absorb the rising watery vapours, but is forced to reject a part, which immediately condenses, and becomes visible as mist or fog. It is easy to see, therefore that this will be the case most frequently in spring and autumn, and in morning and evening. If the condensation of vapours is still further developed, the separate molecules become larger and heavier, and, flowing together, form rain-drops, which fall to the ground by reason of their weight; or, if the upper strata of air are very cold, the masses of vapoury particles are frozen as they cling together, and fall as snowflakes. Sometimes it happens that the snow falling from the upper region of the air is melted as it approaches the earth, so that it snows higher up, and rains below.

Hailstones are generally of cylindrical shape, containing a core, or centre, of snow, surrounded by concentric strata of ice. In our own latitudes they are generally as large as peas, but some have been seen the size of a pigeon's egg. On the 7th of May, 1822, hailstones weighing thirteen ounces fell in Bonn; and on the 15th of June, 1829, the roofs of the houses in Cazorla were shattered by hailstones and falling masses of ice, some of which weighed two pounds. Ice masses like these can scarcely arise by the freezing together of separate hailstones. Hail falls most frequently during the summer months, and may occur at any hour of the day and night. The temperate zones are the true home of the hail, which



Ice Crystals (natural size).

seldom falls in high latitudes, and is altogether unknown in the lowlands of tropical regions, although it falls upon the mountain peaks near the equator. With us hail is generally accompanied by thunder and lightning. In violent hailstorms, the clouds often hang down like a leathern pipe toward the earth. The wind blows in gusts from the most opposite quarters; a rattling sound is heard high in the clouds, and the hail descending covers the ground with a white carpet. In a few minutes all is over. Hail is a local phenomenon; in closely adjoining districts it falls with unequal and varying force. For instance, in the cutting of the Saal, near Jena, hailstorms are unknown, while they frequently visit the neighbouring heights. At Thizy, in France, no hail has fallen within the memory of man, but it hails frequently at eight or ten miles' distance. Certain Alpine valleys suffer yearly from violent hailstorms, while the higher districts near them are comparatively free. The restriction of the storms to long narrow belts was seen most clearly in the destructive hailstorms which visited France and the Netherlands in 1788, in two parallel zones, each of which was about four miles wide, from south-east to north-west, from the Pyrenees to the German Ocean. The zones of hail were separated by a space of fourteen miles, in which space it rained during the hailstorm. The storm advanced at the rate of forty miles an hour. The hail only lasted seven or eight minutes in each place, but the damage done amounted to twenty-five million francs (£1,000,000). The frequency of hailstorms varies considerably in different years, and is probably governed by some universal law underlying the mere local causes. Fritz has shewn that the years of greatest hail very nearly coincide with those when the spots on the sun are most numerous. The cause of hail formation is probably to be sought in upward rising currents of moist air, akin to those which we shall afterwards mention as waterspouts.

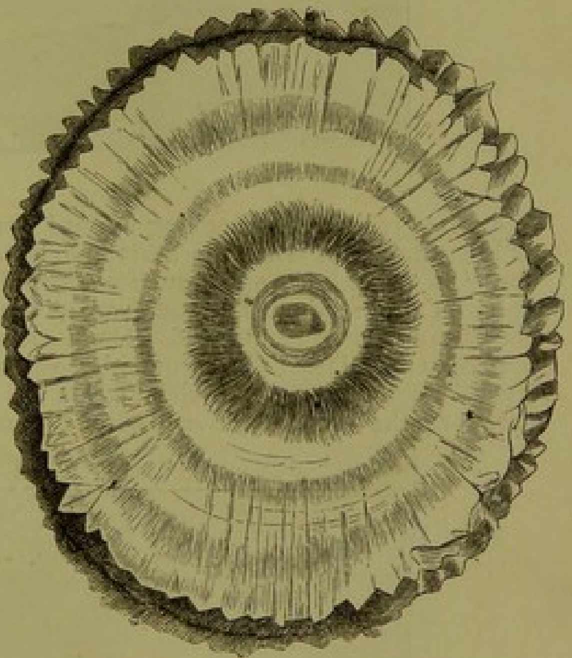
Clouds vary considerably in form, but there are certain types to which the forms may be referred, so as to admit of some kind of classification.

1. Cirrus (curl or feather cloud). To this class belong the small fleecy clouds which cover the blue sky in spring and autumn, and the delicate cloudlets which pass before the moon. They are higher than any other cloud.

2. Cumulus (heaped cloud). These are beautiful cloud masses appearing in fantastic forms, and often taking the shape of a mountain range with brilliantly lighted snow peaks.

3. Stratus (*fall* cloud). A heavy layer or bank of cloud seen at night-*fall*, whence it takes its name. To these belong the rich-coloured sunset clouds, stretching in bands across the horizon.

ICE CRYSTAL, WITH CONCENTRIC LINES.

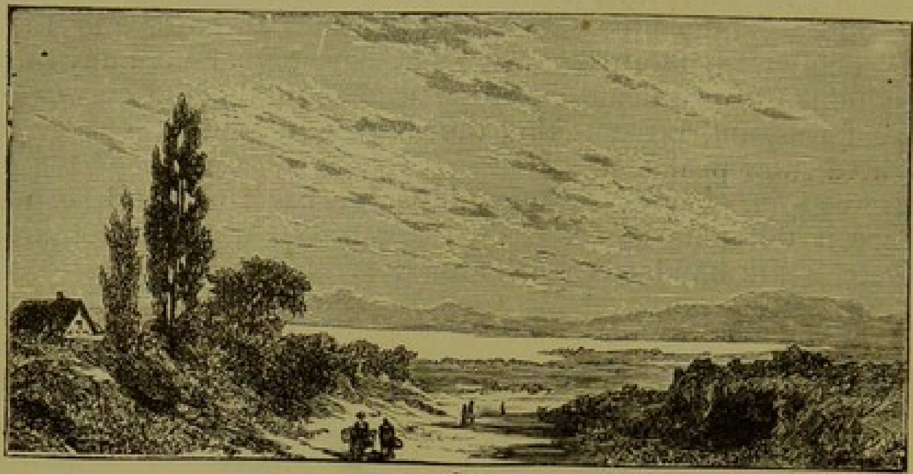


ICE CRYSTAL, WITH RADIATING LINES.

These primary types seldom or never appear in strict regularity of form, but are generally seen in a transition state, often being very difficult to classify. And the cloud-forms are, moreover, in a state of perpetual change, as may well be expected when we remember that a cloud represents nothing complete and perfect, but is incessantly fighting for bare existence.

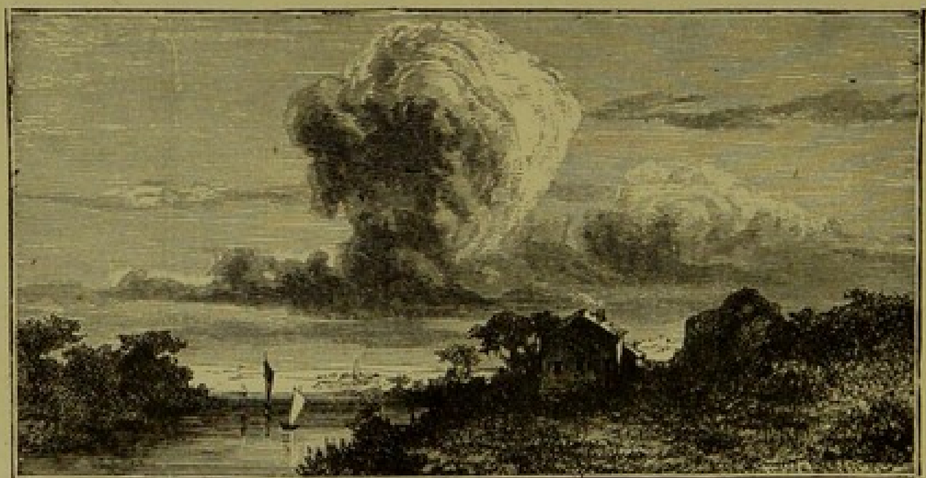
The cirri frequently pass into the feathery cirro-cumulus, the "flock of sheep" of the child's ballad; and in spring and autumn they take a horizontal form, as if the sky had been swept with a broom: in this form they are called the cirro-stratus cloud, or polar bands, because the linear shape betrays an inclination to the magnetic poles. The cumulo-stratus is another combination of two primary forms. The grey, leaden rain cloud which covers all the sky, and pours down fine, steady rain, is called nimbus.

The view which we obtain of the clouds is, of course, one-sided; we can only see the under side, and the impression given is very different from that which would be received by a person standing above the clouds. The aëronauts Tissandier often observed this in the ascents undertaken by them for scientific purposes. They found that Howard's classification, as above given, is quite insufficient. It often happens, for instance, that the sky is clear, but by no means blue; the colour being hidden by light masses of vapour of uncertain form drawn across the sky like a misty curtain. Now when the balloon rises through this layer of mist, it is found to present two very dissimilar surfaces. The surface next the earth is vague and vapoury, gradually fading imperceptibly into the air. The upper surface, meanwhile, appears perfectly flat, of a brilliant white colour, almost like a plain covered with snow,



CIRRUS.

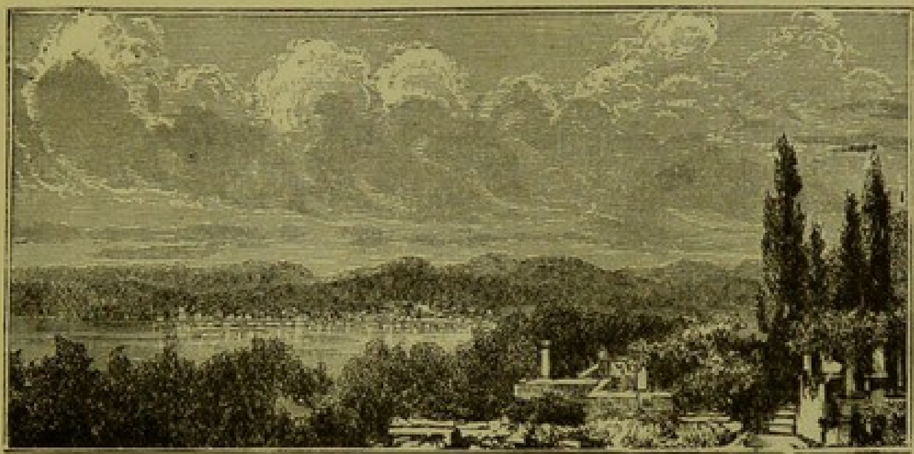
and strongly lighted. Looking upward from the earth, the spectator sees nothing but a more or less thick mist, while the aërial navigator looks down upon a cloud plateau of brilliant cumuli. A bank of vapour such as this, when, as was often observed by Tissandier, it looked upon its upper side as flat and even as the surface of a lake, cannot be referred to any of the classes before mentioned. These cloud masses are found at very different heights in the atmosphere. Tissandier frequently saw them between 1,500 and 3,500 yards above the sea level. Sometimes several cloud strata are seen, one above another. On the 24th of September, 1874, the above-mentioned aëronauts met a bank of cloud of this description two hundred



CUMULUS.

yards thick, at a height of two hundred yards only. On the 8th of November, 1868, they saw four such banks, the first floating at a height of about 1,500 yards, the second at 2,000, the third at 3,500, and the fourth at about 5,000 yards above the sea. The well-known meteorologist, Glaisher, met, on the 21st of July, 1863, five cloud strata, separated from each other only by a short distance. The highest bank was pouring down heavy showers of rain, which fell upon the clouds below, where it passed away as vapour without reaching the earth.

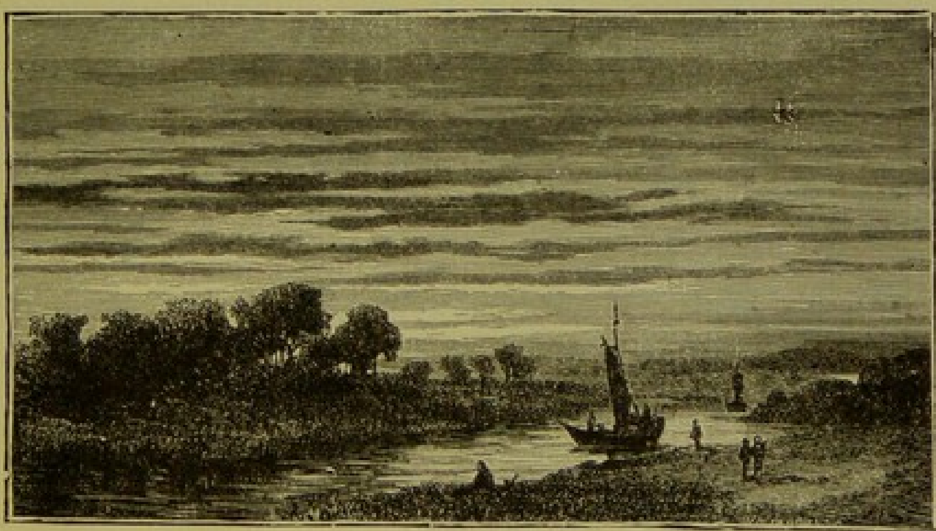
Clouds are found at very various heights. The cirri are the clouds of the upper atmospheric currents, and float far above the loftiest mountain peaks. Gay Lussac saw in his balloon ascent of 7,000 yards, cirri floating above him at a height apparently equal to that at which they are observed from the earth's surface. At such great heights the temperature must be of icy coldness, and the clouds must consist of fine ice crystals. The region of the cumuli lies between about 1,000 and 3,000 yards high. The height of the thunder



CUMULI.

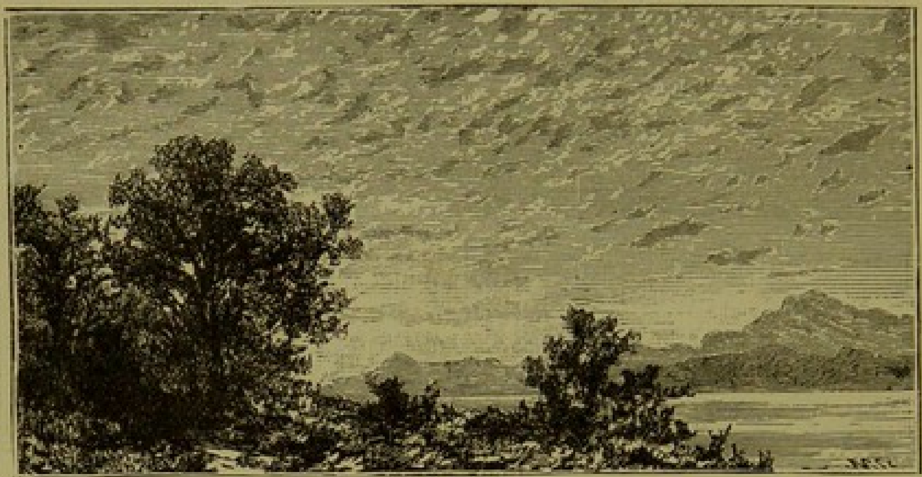
cloud is very various, ranging from thirty to 5,000 yards above the earth. On the 16th of May the writer saw lightning flash from a cloud which appeared to be 4,000 yards high, a height that is equal to that of the Grotz Glockner or Ortels Spitze.

If we turn now to the distribution of rain over the earth's surface, we



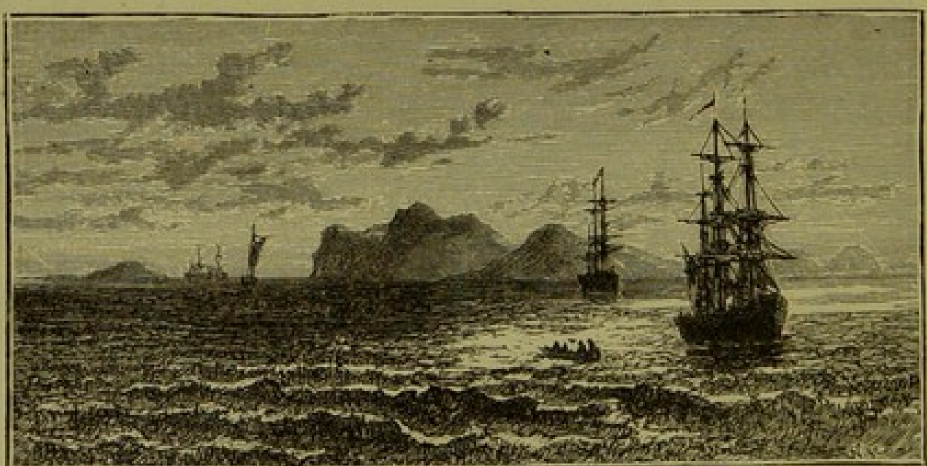
STRATUS.

find, first, that in tropical regions the zone of calms is also a zone of rain, the watery vapour condensing as it rises with the hot air, and falling back in the form of violent rain storms. These tropical rains follow the zone of calms, and wander with it, following the sun, toward the north or south, according to the season. As soon as any place enters the zone of calms, its rainy season begins. Districts in the immediate neighbourhood of the equator enter twice a year into the zone of calms, and have accordingly two rainy seasons, which, on account of their unequal duration, are called the greater and lesser rainy seasons. Most places in the tropics have, however, only one rainy and one dry season; the former corresponding to our summer, and the latter to our winter. They are called by the Indians the time of the sun and the time of clouds. On the coast of the Congo and Benguela, the cool season is called the



CIRRO-CUMULUS.

year of mist, and the warm season the year of rain. From September to May the sun is veiled for days together with monotonous masses of white cloud. North and south of the zone of calms are the bright, rainless zones swept by the trade-winds. The trade-winds are obviously dry winds, because they blow from colder to warmer regions, and the air rushes farther and farther away from its point of saturation. Thus, in the zone of the trade-winds, no conden-



CIRRO-STRATUS.

sation of watery vapour into rain can take place, and on the open sea, where the trade-winds are unhindered in their development, the two rainless zones on each side of the zone of calms are distinctly observed. But if the trade-wind is met by a high land along which the air is forced to rise, the wind can of course be changed to rain. This is the case in South America, where the trade-wind from the south-east, as it advances toward the interior, is gradually forced to rise and discharge its moisture in heavy downpours of rain, to which the luxuriant vegetation of the Amazon River valley owes its existence. If the lofty wall of the South American Andes ran directly from the shore of the Atlantic, or if the flat plain lay to the west instead of to the east of the mountains, the greater part of Brazil would be an absolute desert. Such effects in the configuration of land are found as a matter of fact in Australia. The great dryness of this quarter of the globe is directly owing to the mountain chain skirting the eastern and south-eastern boundary. The south-east wind, blowing from April to August, pours out its watery treasures in heavy rains upon this corner of the land, while the interior receives no moisture. And in like manner the north-west monsoon only moistens the northern line of the coast. Along it rise shadowy forests; plantains and cocoa palms thrive and flourish, while upon the other side of the Torres Straits the vegetation is poor and scanty for want of regular rain. The form of the land and the course of the mountain ranges determine the rainfall, and consequently the fertility of India. Here we find the south-west monsoon, laden with the vapours of the hot Indian Ocean, strike against the Ghaut mountains in the south, and, as it rises and presses northward, deposit its moisture in heavy showers and storms, while the plateau of the Deccan is only washed with moderate rain. And in like manner, the wind coming from the Bay of Bengal pours out such torrents of rain upon the slopes of the Himalaya, that even the true rain storms of the tropics are exceeded by them in intensity. The maximum rainfall in the Himalaya is found at a height of from 3,900 to 4,200 feet above the sea. Within these lines are situated the districts of Dharmsala, Masuri, and others. When in the height of the rainy season, that is, during the months of July, August, and September, the rainfall varies between seventy-five and a hundred inches in height. In the higher regions of the Himalaya, and on the opposite side, in Thibet, the amount of rain decreases rapidly.

NIMBUS.

The rainfall in the temperate zones is very much lower than in the tropics, and the distribution throughout the year is much more equal.

The average distribution of rain in Europe, as found by a long series of yearly observations, clearly shews that in our part of the globe there are two different zones of rain, a south sub-tropical zone, with dry summers, and a northern zone, with rain at all periods of the year. By the sub-tropical regions we mean Spain, the south of Portugal, Sicily, and Calabria, where the rain descends in largest quantities during the winter months; farther northward the rainy season happens in the months of spring and autumn; so that it has two maxima, which are always connected by a rainy winter, and separated by a dry summer, the year being accordingly divided into six months of rain and six of comparative drought.

In the northern zone, with rain in every season of the year, not a day is safe from rain, and a month of dry weather is an extremely rare occurrence. But even here the quantity of rain is not distributed equally through the year. In central and eastern Europe the maximum of rain falls in the summer months, while on the western coasts and in the islands it falls in autumn. In the vicinity of the sub-tropical zone the maximum is found in spring and autumn, but a considerable amount falls there also in summer. The autumn maxima along the coasts are due to the difference of temperature existing at that time of the year between the sea and the mainland. The maxima of the summer months in eastern and central Europe is caused by the moist return trade or equatorial currents not reaching our latitude until the summer solstice, while it reaches the south of Europe in spring and autumn, the south of Spain, Africa, and south Italy in the winter. The more equal distribution of rain throughout the year is owing to the position of central and eastern Europe, which is situated in the district of the changing polar and equatorial currents. The south of Europe, on the contrary, lies within the region of the trades from June to August, and therefore has an almost rainless summer. While in North Italy the maxima of spring and autumn are evenly balanced, the spring maximum is lower in the south of France, and disappears altogether in Bretagne, where, as also in England and Wales, the year has but one, and that an autumn, maximum. In Scotland and Ireland the maximum falls in winter; in Norway in autumn, and on the North Sea coast of Germany and Holland it is found sometimes in summer, sometimes in the autumn, thus betraying the character of the boundary region. There are decided summer maxima in Sweden, Germany, Hungary, and European Russia, as well as in the steppes of southern Russia.

As the rain comes to us with the west and south-west wind, the western coasts are more rainy than the eastern. The contrast is sharply defined between the rainy western lands of Europe and the dry eastern plains of Russia. The continent is not really continental, except to the east of a line drawn from Haff, near the Baltic, to the mouth of the Danube. It is no accident which makes this line the eastern boundary of the beech, the characteristic tree of the sea climate of western Europe. The Iberian peninsula is the only exception to the abundance of rain of western Europe.

The western coasts are more rainy than the eastern, not only as a whole, but in separate localities. Thus, the west of England has more rain than the eastern counties; Sweden is drier and sunnier than Norway, and the coast of Holstein is not so rainy as Dithmarsen. Of course, all else being equal, there is always more rain along the coast than in the interior of the land.

We find in Europe the highest rainfall occurring wherever the moisture-laden wind has to cross a mountain range. The heaviest rains fall in places where high mountains rise sheer out of the sea, as in Norway or Scotland; the rainfall in Bergen is 90·1 inches, Portree, in the Isle of Skye, 103. These figures are exceeded by the Cumbrian mountain range. In Seathwaite, Borrowdale, the rainfall is 154 inches: still more registered at the station on the Stye-Head Pass, namely, 192; the amount is not much less at Glencoe, in Argyllshire, where it is recorded at 130. Similarly we find very high rainfalls in the Venetian and Lombard Alps.

The high plateaus are less rainy than the mountain chains. Even low ridges of land have a higher rainfall than the valleys in the neighbourhood, as, for instance, Pomerania, Upper Silesia, Poland, and the high plateau of Tarnopol. But when we consider the Iberian peninsula, the type of all plateau formations, we do not find the same prevalence of rain. The mountain lands of Asturias and Gallicia certainly have a heavy rainfall, and much rain falls in Portugal, but the interior of these lands is as dry as a Russian steppe. The remarkable dryness of the Ebro valley and the Castilian plain is due to the position of these countries, which are encircled by mountains which absorb the rain, and leave but a scanty and exhausted vegetation to the lands behind them. These Spanish plains, where the drought creates a desolation equal to that of the steppes, are the cause of the decrease of the population, and affect very seriously the welfare of the country.

Among the drier regions of western Europe, with a rainfall of 22 inches, we must mention the neighbourhood of Paris, the valley of the Allier, at Clermont, the valley of the Rhine, north of Mannheim, and Thuringia. To the same district belong the north of Bohemia, the neighbourhood of Presburg, and the Hungarian plain, all surrounded by high mountain ranges which hold off the rain. Perhaps the scarcity of rain along the coast of Mecklenburg and the plain of Saxe-Brandenburg may be explained in a similar manner, for the latter lies in the shadow of the mountain terraces of upper and central Germany, and the former in that of the Harz and Mecklenburg plateau. The amount of rain in Posen and East Schleswig seems to increase in proportion to the elevation above the level of the sea.

The particulars of the distribution of rain in eastern Russia offer no complication. To the north-west of a line drawn from Odessa to Kasan the rainfall varies between 16 and

20 inches, an amount exceeded only in Finland, and, perhaps, in the Waldai mountains. In the steppes, and to the east of the Ural chain, the rainfall is only 10 to 12, and its minimum is reached in Astrakhan. In Siberia the amount of rain seems again to increase.

If we except the south-eastern parts of Russia and the Spanish plains, we must admit that Europe does not, on the whole, suffer from an unequal distribution of rain. The average height of the rainfall of western Europe amounts to about 28 inches, all the land above 34 inches is wet, and all below 22 inches is dry. This favourable distribution of rain corresponds to the peninsular form of the land, and with its rich divisions, and the favourable position of its mountain ranges; for nowhere do we find a high mountain chain extending like a rampart against the south-west wind, but the chief ranges run parallel to the rain-wind.

The Weather.

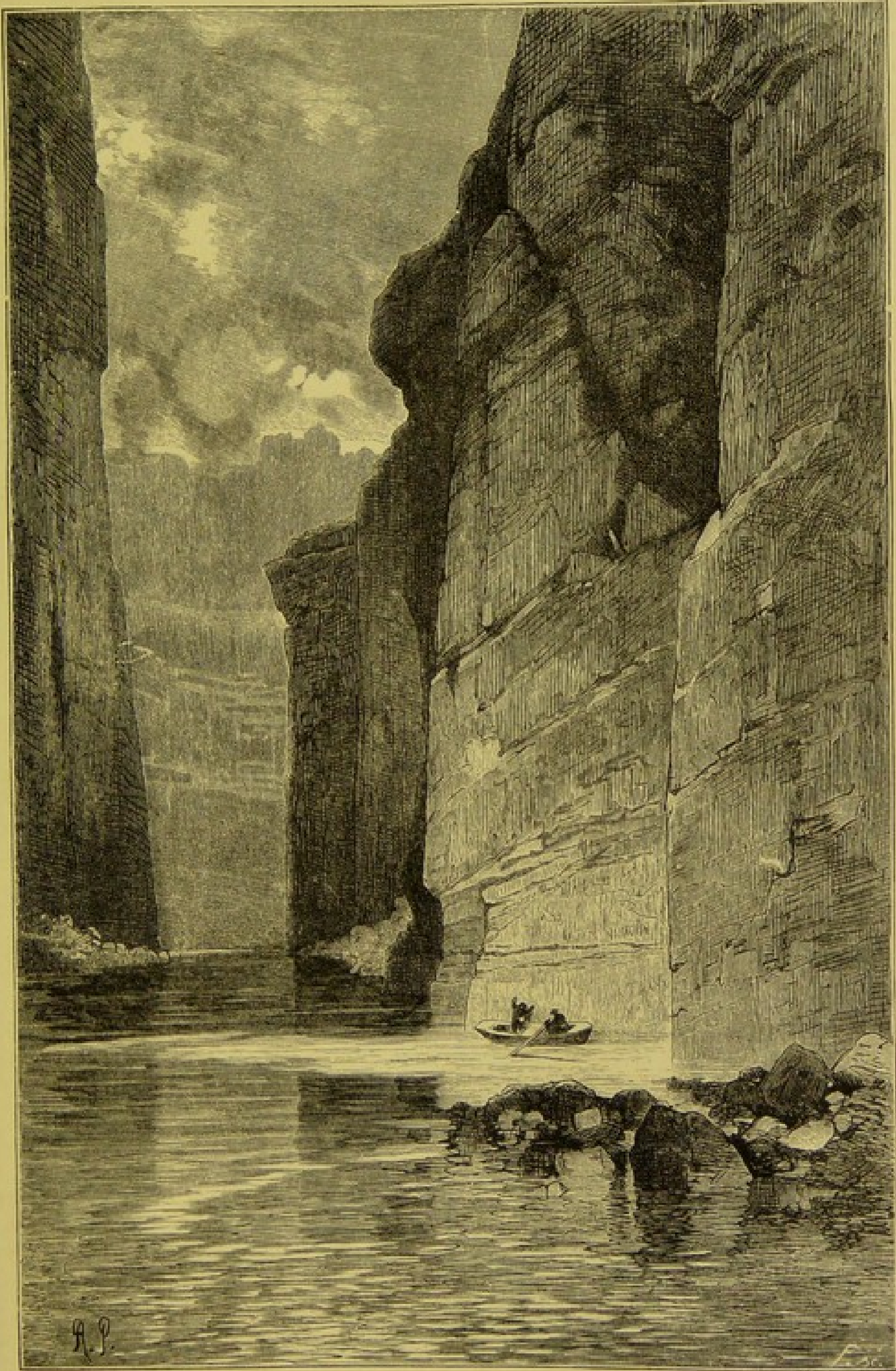
The weather at any place may be described as the combination of all the atmospheric phenomena occurring there at one time, and the average phenomena of the weather existing for any considerable period of time makes up the climate. The distribution and changes of atmospheric pressure have great influence upon the state of the weather; this influence, however, is not *directly* exerted, but indirectly, through the medium of the wind. Wind makes the weather. In order therefore to understand the phenomena of the weather, it is necessary to determine the meteorological character of the different winds, and find out the qualities of the temperature, moisture, cloud and sunshine, etc., as they appear at the times of the different winds. A long series of observations must be taken before the average result can be learnt, and each different season must be compared throughout a succession of years. When the state of the barometer is determined at a given place for every quarter of the wind, and for each month, the *baric windrose* of the place is obtained; and if, in like manner, the temperature accompanying each different wind is learnt, the *thermal windrose* is determined. The windrose can also be made out for the relative moisture, cloud, and rainfall of any place, and has been constructed for a number of localities, especially in Europe. It has been found from these statistics, that in southern and western Europe the south-westerly winds are the lightest, warmest, moistest, and cloudiest; while east and north-east winds bring with them the highest atmospheric pressure, the lowest temperature, the least rain and cloud in winter. In summer, on the contrary, east and south-east winds bring the greatest dryness and most intense heat, and west and north-west winds the lowest temperature and greatest cloud and moisture. In other words, the winds coming from the south bring cloud and moisture, with heat in winter and coolness in summer; the north winds, on the contrary, bring dryness and sunshine, violent cold in winter and great heat in summer. These opposite characteristics of the two atmospheric currents which strive for the mastery throughout the continent of Europe, and neither of which can retain the pre-eminence for any considerable period, determine the changeable character of our weather.

We have already spoken, in our chapter on winds, of the conflict of these two antagonistic currents of air. We there stated that circling eddies of air are formed round the places of lowest atmospheric pressure, round which the wind moves in the opposite direction to that of the hands on a clock. On the fore side of these eddies the winds have all the characteristics of an equatorial current, causing the barometer to fall, raising the temperature, and bringing cloud and rain. On the opposite side the winds have the characteristics of an arctic current, raising the atmospheric pressure, lowering the temperature, and lessening the amount of cloud and rain. Thus we see opposing forces at work on both sides of the barometric minimum. The winds on one side, by causing the fall of the barometer, tend to form a new barometric minimum in front of the central eddy, which is forced to be continually advancing forward; although, of course, it is in new parts of the atmosphere that the new minimum is formed. This advance of the barometric minima does not, however, take place, as we should have expected, in the direction in which the isobars are nearest together, but almost at a right angle from it, in our hemisphere generally from west to east. Sidewards, at a greater or less distance from a barometric minimum, a wide barometric maximum is generally perceived on the metereological charts. The formation of barometric maxima and minima take place in Europe at all parts of the year, but are most decidedly marked in winter. The cause of their greater rarity and slighter intensity in summer is that at that time the moist air is generally at the greatest distance from its point of saturation, and that then the isobars lie far apart, and the winds, as they advance towards the north, can only slowly cool down.

The meteorological records of North America exhibit much the same laws and phenomena as those existing in Europe. The barometric minima advance there also principally from west to east, and escape our circle of observation on the Atlantic Ocean. In many cases eddies of disturbance travel from North America to Europe. The American eddies are distinguished from the European, because the farther they advance eastward, the more wind they absorb from the fore or Gulf Stream side, while the other side receives the winds from the dry and (in winter) cold interior of the land. In the European eddies, on the contrary, as soon as they reach the mainland, the foreside receives the wind from the land, and the opposite side from the sea, which tends to hold back the winds, weaken, and at length fill them with moisture.

The barometric minima on the Atlantic generally appear on the boundary line of the warm North Atlantic Ocean current and the arctic current. Upon this highway of eddying centres Iceland is situated, where the vapour-laden atmospheric currents from the south discharge their moisture, and greatly lessen the barometric pressure. If we turn southward toward the tropics, the number of barometric minima decrease, while the maxima increase; the weather becomes more settled until we reach the constant temperature of the trade-winds. In the equatorial belt of calms, which are regarded as a barometric minimum between the trades, created and supported by the heat of the equator and the amount of watery vapour brought by the trade-winds, the prevailing weather characteristics are heavy rains, unsettled winds, and frequent calms. In the southern temperate zone, which is chiefly taken up by the sea, the wind generally revolves with the sun, which shews that the prevailing north-westerly winds belong to numerous eddies on the north side, whose centres move eastward in higher southern latitudes. The high atmospheric pressure found on the sea along the boundaries of the region of the trade-winds is owing to the fact that in these districts there are numerous maxima of atmospheric pressure, and but few barometric minima. On the arctic side of these regions are zones in which the heat and condensation of watery vapour work as they do upon the equatorial side to maintain a low atmospheric pressure, and the currents of air rising on both sides from these barometric minima fall as dry air in the districts situated near the tropics, and create barometric maxima.

If we examine more closely the movement of the air within the barometric minima, we find that a kind of suction takes place. The air in the



MARBLE CAÑON.

eddy rises toward the centre in a spiral direction, while the vapours condense and fall down as rain. In doing so, the conditions of keeping up and continuing the processes are complied with; and, indeed, a barometric minimum which is no longer a source of rain carries within itself the germ of its own destruction. The cool air rising in the central eddy, and deprived of its moisture, flows toward the point of higher barometric pressure, that is, toward the maximum. This current in the upper air may be recognized by the wide streaming banners of the cirrus clouds which are hung out from the centres of depression, and float far away across the lands. They move in the same cyclone-like direction as that of the lower, in-flowing streams; but while the latter flow inward toward the centre, the upper cirri flow outward. On the fore side of the eddy their direction is found at a sharp angle with that of the lower winds, while on the opposite side they move nearly in the same course. From the direction of these bands of cirrus cloud a fairly trustworthy conclusion as to the position and advance of a barometric depression may be arrived at, and from their density an approximate calculation as to their amount of moisture may be obtained.

Cyclones, Tornadoes, and Whirlwinds.

When the movement of the atmospheric current has attained a certain degree of speed (about thirty yards a second), the wind becomes a storm wind. The storm wind is of course always produced by great differences in the state of the barometer at two adjoining places, that is, by a steep gradient. If, *e.g.*, there is a difference of 0·59 inch in the atmospheric pressure on each coast of the Baltic Sea, stormy weather may certainly be expected in those waters. Generally speaking, gradients of 0·19 inch bring storms, and are known as "storm gradients." In certain tropical hurricanes, gradients of 1·77 inch have been recorded. In the storms of the temperate zones, which, as we know, are created by circular eddies moving round a barometric minimum, only certain parts of the eddy are usually found to have storm gradients. In tropical storms, on the other hand, storm gradients are found round all parts of the minimum, and give rise to the storms known as cyclones. The cyclones change into hurricanes, tornadoes, trombones. A number of intervening degrees are found, it is true, between waterspouts and tornadoes, but the connection between them has been clearly demonstrated by Reye.

Violent whirlwinds are often seen in the midst of great conflagrations. A cane forest surrounded by a few isolated trees on the border of the Black Warrior River in Tuscaloosa, Alabama, broke out into flames, which spread over a surface of twenty-five acres. Whirlwinds of various forms were seen in the hottest part of the fire. At first they were comparatively slight, not exceeding thirty-five or forty feet in height, but as the fire spread they rose to a height of more than 200 feet. The flame and the smoke arising from the whirlwinds were wholly distinct from the general mass sent up by the fire. Even when the fire had burnt out in a great part of the forest, the whirlwinds still rose above the ashes. The wind was blowing from the north-east when the fire broke out, but shortly afterwards the wind blew near the ground from all sides toward the centre of the fire. The columns of smoke rose more than 600 feet vertical in the air, and then suddenly bent toward the south-west, clearly shewing the point at which the prevailing north wind got the upper hand of the currents round the fire.

Immense whirlwinds are often seen accompanying the large clearing fires

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of the backwoods. In the year 1824, seven acres of timber and brushwood were fired at Amherst, on a warm windless day, when the smoke and flame united in a large, whirling, cylindrical column, accompanied by violent roaring. At a similar fire in Stockbridge, the whirlwind was so violent that it tore up young trees six to eight inches thick, and hurled them fifty feet high in the air. Similar whirling columns have been observed above the craters of active volcanoes. On the 8th of April, 1866, a pillar of ashes rose above the volcano of Santorin during an eruption, with the usual thunder and rumblings, and suddenly shot up in the form of an immense steam screw to a height of 19,000 feet. Sometimes the vapours contained in the whirlwinds condense above the column of smoke, and form clouds, sending down lightning and rain.

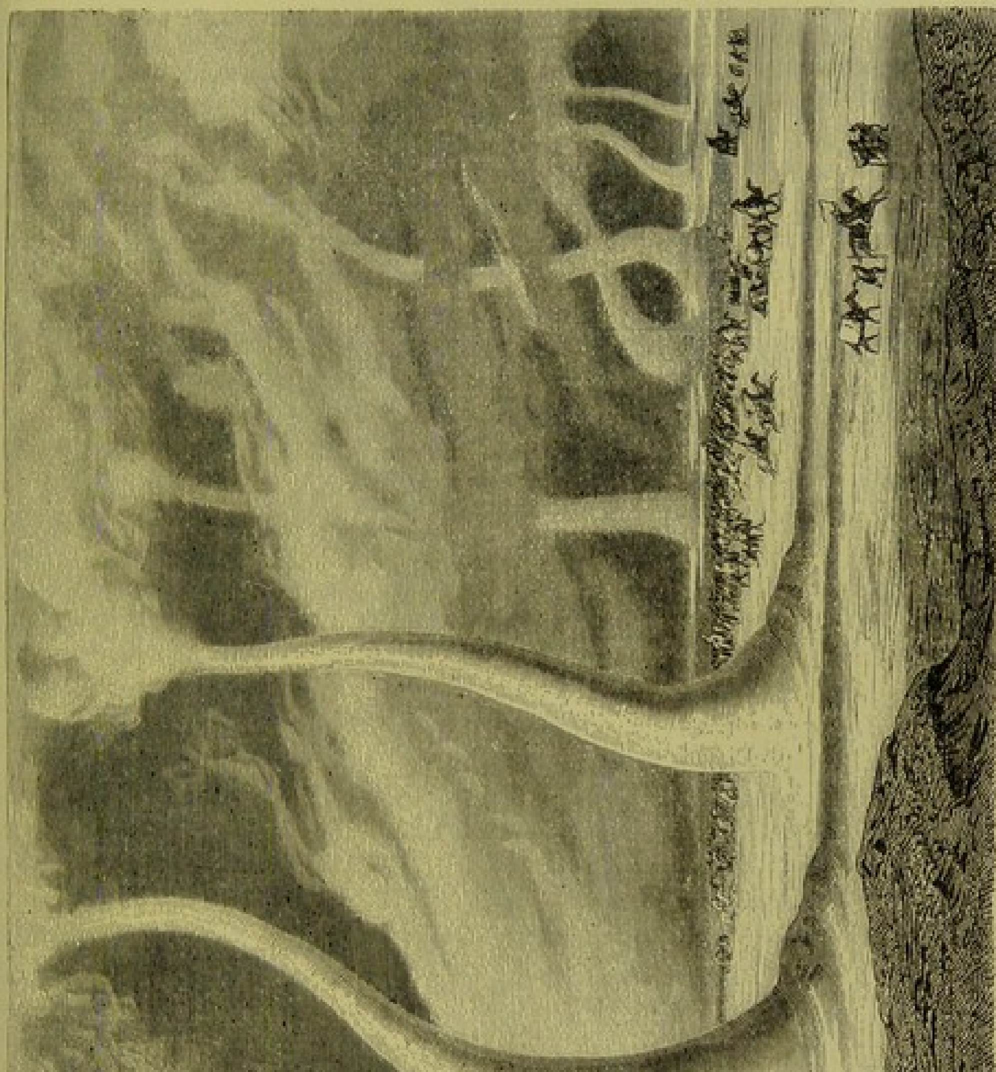
The simplest form of the whirlwind is that observed on calm days, on large squares or cross roads, when sand and leaves are lifted and whirled round for a few seconds. Dust whirlwinds of considerable size are sometimes observed in the Russian steppes; but the best known phenomena of this kind are the high sand pillars of Sahara, which have been falsely reported to be able to bury whole caravans. Even in Australia these rotary dust pillars are met with, generally being seen upon shadowless plains. It is thought that these Australian whirlwinds are the channels which carry the heated air from the ground to the higher strata.

Whirlwinds are generally preceded by a sultry, oppressive air; sometimes by absolute calm; but the state of the wind never appears clearly connected with the phenomena. The storm pillars vary greatly in form; the sand columns being generally funnel-shaped, and the waterspouts like a pipe surrounded at the base by whirling vapours and foaming water. The height and diameter are also variable; some of the highest have been estimated at 6,000 feet. In many cases the damage caused by the water is of such a kind as to shew that there has been an influx of air from every side toward the base of the column.

The disastrous effects of waterspouts are often extremely serious. In the last century, Hainichen, in the Harz mountains of Saxony, was visited by a destructive whirlwind. The wind shifted many times during the day, and there were heavy masses of thunder clouds rolling rapidly across the sky. About four o'clock in the afternoon, at a distance of one or two miles from the town, an appearance like a long tube of vapour descended from the clouds toward the earth. Several times it was drawn upward again, but at last it reached the ground, and then advanced with terrific speed, rushing forward at the rate of four and a half miles in eight minutes, destroying all within its path.

It started from Arensdorf, where it tore down roofs and houses; at Dittersdorf it wrecked a newly built farm-house, with all its dependencies. The massive dwelling house was utterly ruined, with the exception of the left wing, which was carried three yards from its original position. The roof and the granaries, which were all full of corn, were found in an adjoining pond. Then, having thrown down several houses, the whirlwind turned aside into a neighbouring forest. In a few seconds a path one hundred feet in width was cleared right through the forest; not a tree or shrub in the doomed track was spared; oaks and linden trees were torn up, and broken to pieces. As a farewell exploit, the column lifted up a groom and two horses, and deposited the latter in a neighbouring coppice, and the former in a ravine. It then divided into several parts, and vanished as it had come, without a trace remaining.

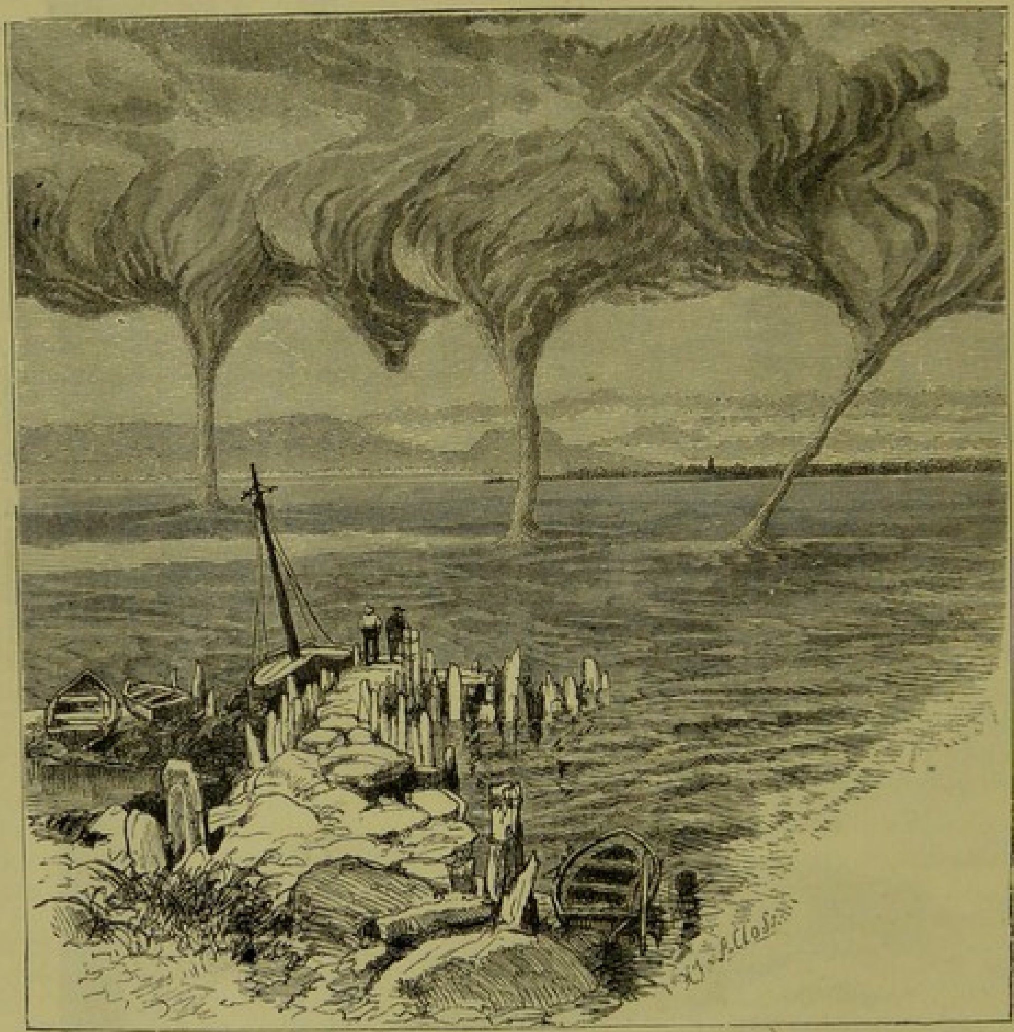
On the 26th of August, 1826, a whirlwind devastated the town of Carcassonne, which had already been visited by a similar phenomenon in the preceding November. A hot south wind was blowing in the morning, increasing toward mid-day, and piling up masses of storm clouds. Suddenly the clouds were seen to descend toward the earth in various directions, as if attracted by it. A dull sound was then heard, ending in a terrific crash like thunder. The air from every side streamed violently towards a dark cloud. Another loud detonation followed, and a reddish column was seen descending to the ground, and overthrowing all within its track. A young man was caught up by it, and dashed against a rock, so as to cause instant



Sand Pillars in the Desert.

death. The advancing whirlwind tore up the strongest trees, threw down walls, loosened great masses of rock, and rushed toward the castle. There it threw down the stone entrance gates, and breaking through the roof, shattered the storeys of the house with a crash like thunder. Passing farther on, it tore up the pavement, broke down a wall, threw a waggon into a ditch, and uprooted several trees. The unwelcome visitor vanished, leaving a strong smell of sulphur behind, and ushering in a violent rain, after which the wind veered to the east, and the sky cleared.

As to the cause which produces these whirling columns, it is considered by Reye to be the action of vertical currents of air, which send up spiral streams of hot air from the surface, or bring down the cold air from the upper



WATERSPOUTS IN LAKE CONSTANCE.

regions. The suddenness with which these columns are formed, even in the calmest atmosphere, and the violent character of their appearance, seem to indicate that they are preceded by an unstable equilibrium of the air, and that they create violent displacements of the atmospheric strata in order to restore the equilibrium. For if the air were in a state of perfect equilibrium, the movement of a slender current of air would quickly spend itself against the passive resistance of the quiescent strata which it breaks through, just as we see it do in the columns of smoke which ascend our chimneys. Now, it is easy to account for the presence of such disturbed equilibrium in a calm atmosphere; for on sunny, windless days a higher temperature is gradually imparted to the lower strata of the atmosphere, so that they slowly expand. In a disturbed air these heated strata would speedily rise like bubbles of steam in boiling water, ascending in masses of greater or less size, while in other places the cold air would sink downward, and spread itself over the ground with a movement such as we see in the trembling of the air above furnaces, heated gravel paths, etc. But in circumstances more favourable to their development, the lower atmospheric strata may locally receive so much heat that they become specifically lighter than the air which rests upon them. Such is the case with the "false mirage" of the desert, which is not seldom seen for a few minutes before the outbreak of the dreaded storm; and then any accidental shock, the appearance of a horseman, or the shadow of a cloud may overthrow the tottering equilibrium, and the gradual accumulation of heat suddenly set in motion rushes upward, tearing with it whirling masses of dust and sand.

We must now speak of those phenomena which are sometimes classed by American meteorologists with whirlwinds, and sometimes among hurricanes, namely, tornadoes. Similar in form to waterspouts, they exceed them greatly in extent, their path often being a mile in width, and their length varying from two to several hundred miles, while they move at the average rate of forty miles an hour. With very few exceptions, all tornadoes move eastward, with a slight deviation toward the north, and sometimes several are seen rushing in parallel courses of from twelve to sixty miles apart. The tornado advances in leaps and springs, passing over the tops of trees, and descending to the ground at intervals.

The current of air in tornadoes is generally directed toward the centre, while in cyclones it has a spiral movement, and in our hemisphere moves in a direction contrary to that of the hands of a clock. In the southern hemisphere, however, it moves with the clock. The cyclone does not blow with regular force, but in violent intermittent gusts and squalls, with an accompaniment of torrents of rain, and mostly thunder and lightning. The day is almost as dark as night. The lower storm centre draws in the moisture-laden masses of air, while overhead the gloomy storm clouds are dispersed outward with terrific rapidity. The sky is black with heavy clouds for hundreds of miles round the true storm centre. These clouds gather in the upper air, and growing darker as the day advances, slowly sink almost to the earth itself. Then the rain begins in unbroken floods that continue incessantly day and night, as if the dams of a great river were broken through, and its waves poured out in masses on the earth below. The barometer falls lower in proportion to its nearness to the storm centre and to the violence of the storm. The fall of the barometer is the most unfailing sign of the approaching hurricane. A little time generally elapses before the outbreak, but sometimes the storm bursts over the country so suddenly that the barometric warnings are too late. In the terrible typhoon of the 6th of October, 1831, the storm broke at the very moment that the barometer fell, so that the ships in the harbour of Mako could take no precautions, and thousands of ships were lost. In the China seas these sudden outbreaks of typhoons are by no means of rare occurrence. There are, however, certain general signs by which the approach of the destroyer may be heralded. Very fair weather, attended by an unusual transparency of the air, great heat, and calm, with high barometric markings during the south-west monsoon, are very suspicious to the sailor; and if at the same time the sky is seen to assume a strange red colouring, with rugged clouds moving swiftly against the wind, a heavy sea, and a dark bank of cloud in the north-east or south-east quarter, there is no longer room for doubt. In the Bay of Bengal, cyclones are generally formed when there is no strong atmospheric current moving over its waters; the air is usually calm, or only stirred by light, variable winds, the atmospheric pressure being nearly equal along all the coast, and only a little rain falling on the eastern and northern coast of the bay, and in Bengal. On the other hand, ships in the centre of the bay, crossing the focus of the cyclone, meet with incessant rains and a temperature lower than that of the surrounding coasts. Finally, a gusty west wind blows from the equator, and when a barometric depression is formed in the centre of the bay, rushes into it, and furnishes the principal aliment of the storm.

One of the most disastrous of this kind of storms was the tornado of the 10th of October, 1780, remembered chiefly for the destruction of the British fleet under Rodney. About a week before the outbreak of the whirlwind itself, a hurricane in Jamaica destroyed the ships *Scarborough, Barbadoes, Victor*, and *Phœnix;* while the *Princess Royal, Henry*, and *Sir Austin Hall*, in the harbour of Savanna-la-Mar, were loosed from their anchors, and driven high and dry upon the land, where they were afterwards used as dwelling houses. The centre of the storm of the 10th of October advanced across Barbadoes toward Santa Lucia, and its outer limits reached Trinidad and Antigua. In Santa Lucia the hurricane struck the squadron of Admiral Hotham, after which it destroyed a French convoy of two frigates and fifty transport ships at Martinique, only six or seven vessels being saved. The storm centre then made its way to Porto Rico, where the *Deal Castle* foundered, and advanced, *viâ* Mona, to Silver Keys, where the *Stirling Castle* went down. The same fate befell the *Thunderer*, above which Walsingham's flag was flying. When the storm had travelled to the twenty-sixth degree of north latitude, it turned sharp round to the north-east, meeting the dismasted ships *Trident, Ruby, Bristol, Hector*, and *Grafton*, with Admiral Rowley in command. The hurricane then made its was to the Bermudas, whence the disabled *Berwick* was being despatched to England for repairs. No less havoc was wrought among the islands of the West Indies. Nine thousand men perished in Martinique: one thousand in St. Pierre alone, where not a house was left standing. The sea rose twenty-five feet high, and 150 houses disappeared from the shore in a moment. In Port Royal, the cathedral, seven churches, and 1,400 houses were thrown down, and 1,600 sick people were buried under the ruins of the hospital, a few only escaping. Almost all the houses built on the shore of Dominique, the royal baking establishment, the magazine, and a part of the barracks, were destroyed. In St. Eustace the storm shattered seven ships against the rocks of North Point, and out of nineteen others, which had broken from their moorings and drifted out to sea, only one returned. In Santa Lucia, where 6,000 persons had perished, the most massive buildings were levelled to the ground, cannons were dashed to a distance of a hundred yards, men and animals were lifted into the air and hurled to the ground. The sea rose to such a terrific height, that it destroyed the fort, and sent a ship crashing against the sailors' hospital. Even the coral reefs covering the bottom of the sea were rent and tossed so that they were later seen above the surface of the water. Out of the six hundred houses at Kingstown, in St. Vincent, only fourteen were left. Rodney wrote in his official report, "Nothing but my own inspection could have convinced me of the possibility that the wind could produce such a sudden and complete destruction of a fertile island like Barbadoes." In the Leeward Islands, the governor's family retreated as the storm grew more violent to the interior of the house, where the walls, which were three feet thick, seemed to promise safety. The wind, however, broke through; the inmates escaped to the cellar, but here the water had risen four feet high; they then proceeded to the battery, and sought the shelter of the cannon; but a few twelve pounders were carried 420 feet away. When the day broke, the neighbourhood looked like a winter landscape, not a twig, not a leaf, upon the trees.

The hurricanes of the tropics are fortunately not so frequent as the wide-spreading whirlwinds of higher latitudes; if they were, ocean traffic, and indeed land traffic also, between certain countries, would be rendered almost impossible. Cyclones are generally met with in the summer months; the typhoons of the China Sea are most frequently seen at the time of the south-west monsoon, but also in the first months of the north-east monsoon. The most dangerous months are those in which the change of the monsoon occurs, especially September, and even October, while the first four months of the year are perfectly free from these storms.

The advance of the tropical whirlwind is very remarkable. At the beginning of the present century it was found that the storms rising in the tropics suddenly change their usual direction from the south-east to the north-west, when the sun crosses the line, and move from the south-west to the north-east. The storms of the southern hemisphere, which in the tropics have their direction from the north-east to the south-west, bend aside as they enter the southern temperate zone to a direction from the north-west to the south-east. The typhoons of the China seas are very irregular in their course. This is especially true of the typhoon north of Formosa, and between China and Japan, where they generally blow from the land to the sea, and then backing suddenly, blow toward the land. But as a rule the typhoon moves round the storm centre in one steady course, which in the northern hemisphere takes the opposite direction to that of the fingers of a clock.

The true birthplace of the cyclone is most uncertain. Some of the Atlantic whirlwinds have an African origin; thus a hurricane which crossed the ocean from Cape Verde rounded the coasts of the United States, affecting the coasts of Newfoundland on the one side, and Great Britain on the other; and after a furious course of thirteen days spent itself as it approached the Arctic Ocean.

The creative germs of the cyclones are found in the upward currents of the lower strata of the air, which rise in great masses from many different causes in warm, moist streams. In some cases the rapid formation of wide-spreading masses of cloud may produce a strong upward current of air; even waterspouts may tend to the creation of the cyclone. The air rushes in from all sides to fill up the vacuum left by the ascending strata, and rises after them—a movement kept up and fostered by the watery vapours. The only reason why there is no creation of a *centripetal* storm is the rotation of the earth. If, *e.g.*, the space from which the air has risen upward is found in the northern hemisphere, the atmospheric currents rushing in to replace it from the south are turned aside toward the east by the rotatory movement of the earth; and those which come from the north are left behind toward the west, the tendency being to move from the north by the west to the south and the east. If the storm centre is in the southern hemisphere, the same causes will produce a tendency toward a movement from the north by the east to the south and the west. If it were possible for the currents of air to advance without any whirling movement toward the storm centre, the low barometric pressure could not be long maintained; the moisture-laden strata of the lower air would soon be exhausted for a considerable space round the centre, and the latent heat of the vapours would cease to act. The American tornadoes and the less violent sea tornadoes furnish examples of hurricanes of this nature—violent indeed, but extending only over a surface of a few miles, in which the influence of the earth's movement is not felt as it is in the great cyclones. It is not felt because the influence of the rotation of the earth on the currents of air is weaker in proportion to the small extent of the storm centre, or place where the air rises, and leaves a space for the incoming currents. The sea tornadoes, moreover, generally occur near the equator, where the movement of the earth is least perceptible. As to the motion of the cyclones, it is clear that it will be directed toward that side whence the warmest and moistest air has ascended for the longest period of time, and where, accordingly, the heaviest clouds are formed, and the greatest rain descends. Experience fully bears out the theory we have just stated. The parabola described by the course of the storm centres is determined by the form of the warm currents in the sea above which the cyclones advance. As a rule, cyclones do not appear to traverse a great extent of space, except where there are warm sea currents over which they can move, as along a definite track. As to the West Indian hurricanes, Reye thinks it probable that the Gulf Stream causes their north-easterly deviation; but when we observe the correspondence between the cyclones of the Atlantic and Indian Oceans and of the China Sea, and the warm currents flowing through these waters, we can have no doubt that the curve of the storms is decided by the course of the currents we have mentioned.

Electric Phenomena of the Earth's Atmosphere—Thunder Storms—St. Elmo's Fire.

The air is always slightly charged with electricity. By night or by day, with a clear or clouded sky, the electrometer marks the presence of electricity in the atmosphere; positive electricity is seen when the sky is clear, and gains in intensity as the moisture of the air increases; in rain and snow the electric condition changes often, and negative electricity prevails. This permanent electric condition of the atmosphere entirely escapes direct observation, while its presence, as manifested in the grand phenomena of the thunderstorm, forces itself on the notice of the most unobservant. The thunder cloud, generally of the massive cumulus order, is known by its peculiar shape. Beccaria mentions it as an unfailing sign of an approaching storm when thick clouds form very rapidly in a clear sky in any point of the horizon. These clouds are boldly and sharply outlined, like the snow-clad peaks of a mountain range; they then seem to develop outward from the centre, losing their clearness of outline; and lastly, the separate masses join together, so as to form only one large cloud.

Large quantities of free electricity are found in these thunder clouds, acting upon the surrounding objects to a considerable distance, in such a way as to attract one of the two kinds of electricity, and to repel the other. Under this influence, bodies which in other conditions betray no signs of electricity become strongly electric. Their electric balance is disturbed. One kind of electricity is attracted by that within the clouds, and the other is brought down to the depths below. This creates an electric tension, the endeavour of the opposing electric currents to unite and restore the equilibrium being hindered by the resistance of the atmospheric strata. If, however, the resistance is finally overcome, the union takes place with a strong electric spark which we call lightning, and a consequent violent commotion of the air, or clap of thunder.

There are three different kinds, or rather forms, of lightning; forked lightning, sheet lightning, and globular lightning. The two former kinds last during a small fraction of a second, and consist of a number of momentary discharges, the globular lightnings are of much longer duration and of rarer occurrence. They generally appear in the form of fireballs moving slowly through the air, entering dwellings, and exploding with a loud report.

The following instances of the descent of these so-called *fireballs* may be of interest.

On the 4th of November, 1749, the English ship *Montague*, 42° 18′ north lat. and $11\frac{1}{2}$° west long., suddenly observed a bluish ball of fire, as large as a millstone, rolling along the surface of the ocean toward the ship. The weather was fair, and the time a few minutes before noon. At a short distance from the ship the ball rose from the sea, and lighted on the mainmast with a crash like the discharge of many cannons. The mast was split open from top to bottom; five sailors were thrown stunned upon the deck, and one of them was severely burnt. The meteor, in vanishing, left a strong smell of sulphur behind.

In the year 1826, after a clap of thunder, a fireball as large as a hen's egg suddenly entered the house of Van der Smissen, ran across the floor of the room where he was sitting, crossing the polished floor with the speed of a mouse, plunged down along the landing of the staircase which led to the basement story, and exploded without doing any damage.

On the 8th of February, 1860, at half-past one in the afternoon, the school house of Bouin, department of Loire, was struck by lightning just as the scholars were saying grace after dinner. The first sign that the room had been struck was the falling of fragments of chalk, wood, and stone among the children. Great confusion ensued, and a small fireball was seen rolling under the forms past the teacher, whose clothes were slightly scorched. His son, who was sitting under a lamp, was killed, as were also three or four of the other children. The ball then gained the open air by passing through a pane of glass, in which it bored a hole, without otherwise damaging it, while all the rest of the panes were smashed to pieces.

The influence of the storm cloud is communicated to every substance, but it is only perceptible in those which are good conductors of electricity, such as metals, running water, moist ground, minerals, and vegetable life. The strength of the electric influence is affected by the shape and size of the separate bodies, and by the more or less uninterrupted communication with the earth. The only sufficient conductor for the mass of electric fluid contained in the lightning is found in the waters flowing beneath the surface of the earth, and forming connecting channels with the rivers and the oceans. These subterranean waters are charged by the action of the storm cloud with the opposite electricity to that which it contains—they form, as it were, an electric cloud underground—and the lightning seeks to equalise the opposing currents, choosing the path along which it meets with the slightest (electric) resistance. Any building, tree, or living being on this path receives the shock destined for the waters in the earth. It is the aim of the lightning conductor to offer a course so well directed by artificial means, that the lightning shall choose it in preference to any other.

The lightning conductor neither diverts the course of the lightning nor diminishes practically the electricity of the storm clouds. Its true method of action consists in offering to the lightning a safe path by which it may gain the underground waters. It would be difficult to solve this problem, were it not that the lightning is attracted in an especial degree by metal and by high, pointed objects. If these qualities can be united in an apparatus placed where there is no other equally good conductor in the neighbourhood, and if it furnishes at the same time a safe passage for the lightning to the moist earth, it fulfils all the conditions of a trustworthy conductor. The conductor must in all cases reach to the masses of water underground—moist strata of earth are not enough; and these waters must not be isolated from the ground, like the cisterns round a house, for a small, isolated quantity of water is not sufficient to neutralise the flash. In this respect a great number of our lightning conductors are utter failures. If the buildings provided with lightning conductors are seldom struck by lightning, it by no means follows that the conductors act rightly, but only that the attractive influence of this and the surrounding projections exerted upon the lightning is less than that of the changeful proportions of moisture. Out of all the countless flashes of lightning, scarcely one in a thousand reaches the earth; most of them are spent in the atmosphere, or, to use the chemical expression of physical science, are neutralised. There is, of course, no doubt that the objects generally supposed to affect the course of the lightning really exert the influence attributed to them—such, for instance, as high, isolated places, quantities of metal, etc.; but this influence is only of relative importance: taken absolutely, and in comparison to that of the atmospheric moisture, it is in most cases reduced to zero. We frequently hear of instances in which large masses of metals, even when found in places which might be thought to be particularly exposed to the flash, had absolutely no effect upon the electric fluid. Our railways are striking examples of this nature. Although they apparently combine every element of attraction, height above a level plain, large quantities of metal, considerable speed, a strong draught of air, and clouds of steam, yet a train struck by lightning is an extremely rare occurrence. Very different is the case with sailing vessels on the sea. The attraction felt by the lightning toward the earth is much stronger on sea than on the land, and therefore an object rising from the surface of the ocean is much more exposed to the path of the lightning than an object of similar height on land. The great number of ships struck by lightning, in spite of their being provided with conductors, is a sign of what might be expected from similar conductors attached to buildings if the atmospheric moisture did not intervene to determine the path of the lightning.

We have said that the lightning seeks, by preference, high objects, especially those which run upwards to a point. Steeples, masts of ships, and high trees are therefore most exposed to danger. If upon a wide plain there is no object of any considerable height raised from the surface, a hedge or fence will suffice to draw down the electric fluid. Sheaves of wheat or haycocks are frequently struck, and almost every village has its legend of some unfortunate labourer killed by lightning under the haycock beneath which he sought refuge.

The lightning will even break solid masonry to reach metallic substances. In the year 1759, an escort of French soldiers halted at the foot of a rampart surrounding a little chapel, to find shelter against a heavy thunderstorm. The chapel was a low building, without tower or steeple, but two of the soldiers were immediately struck dead by a flash. The lightning tore open the wall behind them in a vertical rift, extending to a great height, and made its way to some iron rods near a monument in the chapel. None of the soldiers were hurt except the two who happened to be standing in front of the metal.

Thin surfaces of metal have been melted by the ray of lightning, but it has never been found that a square bar of metal half an inch thick was melted by the action of the electric fluid. Sometimes the lightning calls forth magnetism in the iron substances found upon its path, and it frequently affects the position of the needle in the mariner's compass.

Lightning is specially attracted by moist air, smoke, and the vapours rising in rooms crowded with men or animals; but the question as to whether it is also attracted by running, riding, and driving, is still undecided, and we must await the results of further investigations.

At times it is known to set fire to the objects which it encounters, and at others to crush and destroy very inflammable substances, without kindling any fire. A similar action is often observed in the spark sent out by the electric battery, which, if it is very strong, does not fire the gunpowder to which it is conducted; but if weak, infallibly occasions an explosion. The explanation of this fact is to be found in the principle of the convertibility of energy.

The action of the lightning is often felt only at each end of the object through which it passes; at any rate, it is always strongest there. Its chemical action is, however, still clouded in mystery. The formation of ozone under the influence of atmospheric electricity is well known, as are also the liquefying and vitrifying effects of the electric fluid. But when we consider the important part already played by electricity in the science of chemistry, we cannot doubt that the lightning acts chemically in many ways of which we are at present ignorant. Liebig was the first who discovered the development of nitric acid in the atmosphere during a thunderstorm.

A singular property of the lightning is its power to trace the outlines of distant objects on the surface of the bodies through which it passes. The fact itself cannot be doubted, but no satisfactory theory has yet been found to account for it, any more than for the explanation of a somewhat similar case vouched for by Grand, the founder of the Academy of Science in Copenhagen, who states that the frost traced upon the windows of a coach, when standing still, an accurate outline of the surrounding scenery.

It is certain that those who are killed by lightning suffer no pain, for persons who have been rendered unconscious by the same cause do not remember seeing the flash or hearing the thunder. A flash, therefore, which has been seen is no longer to be feared. The look of one who has been struck dead by lightning betrays no sign of the terrible power to which he has fallen a victim; the position and attitude of the body is generally unchanged. We hear from Reimarius, that two men who had sought shelter behind a hedge were killed by a flash of lightning, and found sitting with open eyes, just as they had placed themselves before death. One of them held in his hand a piece of bread which he was offering to a dog sitting upon his knee, and struck dead with his master.

When a sandy plain is struck by lightning, the grains of quartz are melted and changed into vitreous tubes, called fulgurite. This fact was first discovered in 1805, on the heath near Paderborn, by Von Hentzen. The tubes are generally about one-third to half an inch in diameter, and not unfrequently go down nearly ten yards below the surface of the earth. Sometimes the principal tube is divided into several branches, each of which has still smaller branches, so that the hole looks like a large root of a plant. For a long time, indeed, the fulgurite tubes were considered to be petrifactions of vegetable roots, or masses of shells of worms. But quite apart from the fact that the sand strata in which they are found are exposed to every change of wind and weather, and make it impossible to ascribe any considerable age to the formations, it has been proved by direct observation that they are created by the fusing and vitrifying effect of the lightning upon the grains of quartz.

Numerous fulgurite tubes have been found on the upper parts of the north-west side of the Little Ararat, a mountain principally formed of fine-grained andesite, rich in hornblende. The quantity of fulgurite is so great, that it has produced a modification of the rock itself, which it is proposed by Abich to call fulgurite-andesite. A great part of the massive rocky portions of the summit are composed of this stone. The fulgurite tubes are so interwoven and pressed together in hollow worm-like cavities, that instead of a compact stone, with microscopic crystalline grooves, we find an imperfect vitreous product, whose metamorphic properties may be compared to those of wood completely destroyed by mussels. Although large fragments of this rock were easily detached by hammers, Abich was not able to determine the approximate depth to which the fulgurite penetrated into the mass of rock.

The frequency of thunderstorms, and their distribution through the four seasons of the year, varies considerably in different quarters of the globe. From the calm, rainless Peruvian coast to the Belt of Calms, where almost every day brings with it some grand electrical disturbance, we pass through every stage and degree of frequency. Even the cold zones are not exempt from thunderstorms. Accidents caused by lightning have been recorded both in Iceland and Spitzbergen. In some places in North Africa they are wholly unknown. The hot simoom appears there as the bearer of electricity. As far as Europe is concerned, the number of storms in autumn and winter increases toward the coast, but everywhere they are more frequent in summer time. Most thunderstorms occur in Europe in the north-east coast region of the Adriatic Sea. From this place they decrease in number toward the north and north-east. If it were attempted to draw a line between all the places where an equal number of storms occur in the course of the year, it would be found that it is impossible to obtain symmetrical curves analogous to the isothermal lines.

As to the frequency of storms, the observations as yet made are too defective, and moreover they depend on a complication of circumstances which vary locally, so that in this respect satisfactory results can only be obtained by a searching examination of small tracts of land. Little is known also as to the movement of storms across the land. It is, however, certain that they advance chiefly on the south-eastern side of the storm centre, and with it traverse a part of Europe. Their speed amounts mostly to eighteen or twenty miles an hour. We must not suppose, however, that in these storms the strata of the thunder cloud pass over the lands discharging their electricity, but rather that the circumstances which necessitate the generation of the storm cloud are developed from place to place. These rotary storms arise in moist, warm, ascending currents of air. Another class, known as erratic storms, are produced by ascending currents on hot summer days, and must be considered as local phenomena; they often happen, however, at the same moment as the great regularly advancing storms; so that both causes work together for the generation of thunderstorms. Sometimes a rotary storm is the sole cause of thunderstorms, which then advance in a very regular course. In other cases the rotary storm, as it passes, only acts as tending to the formation of local thunderstorms, which then break out sporadically, and more especially over favourable regions, such as forests and mountain chains. In this case the movement in advance takes place by leaps.

The beautiful silent phenomena known as summer lightning, and frequently seen on sultry summer nights in all parts of the heavens, are but the reflection of distant lightnings, or belong to a special kind of electric disturbance which goes on noiselessly for us in the cloud masses. In the course of a series of observations, extending over many years, we have seen this kind of lightning sometimes starting from small clouds, which slowly moved along. In the year 1805, Muncke saw, on a summer night, a small cloud in the heavens, from which irregular, intermittent lightnings flashed; and many other instances of the same kind are reported.

Sometimes various and singular electric phenomena are seen near the surface of the earth. Livingstone reports that the air in South Africa, when the wind in the dry season blows over the hot desert of Kalahari, becomes so strongly electric, that a bundle of ostrich feathers held for a few minutes in the current of air is as strongly charged as if it had been connected with a powerful electric battery. At every movement of the person, electric sparks are sent out; and if the clothes are rubbed, they immediately begin to shine.

In California also the air in dry, sultry weather is so laden with electricity that the trees crack, and a pale spectral light glides through the depth of the forest, while the pines exhale a strong resinous odour. This phenomenon recurs several times, but with decreasing intensity, until the light resembles very faint moonlight. Strange as this description sounds, a somewhat similar phenomenon was observed in Europe on the 11th of August, 1854, in the form of a wonderful light cast on the Grands Mulets (Mont Blanc), which could not be referred to moonlight or any artificial illumination.

In the year 1767, Saussure, on stretching out his hand during a thunderstorm on the summit of the Breven, noticed a strange tingling in the tips of his fingers. His companion, who wore a gold braid round his hat, heard a rushing sound near his head, and sparks were extracted from the gold button

St. Elmo's Fire.

of the hat and the metal knob of a cane. Similar phenomena have been not unfrequently noticed since the one in question, but no scientific explanation of their origin can yet be given.

Another unexplained electrical phenomenon is that well known in ancient and modern times, and called St. Elmo's fire.

Cæsar tells us that in a stormy night, while hail was falling, the javelins of the fifth legion appeared tipped with flame; and Pliny has recorded similar appearances on the lances of the sentinels keeping guard on the fortifications by night.

Many such lights have been noticed on the masts of ships in ancient times. Plutarch tells us that when Lysander and his fleet sailed from the harbour of Lampsacus, two flames were seen on each side of the admiral's ship. The appearance of two flames was considered in ancient times, and even in the middle ages, to be of happy omen, but a single flame was looked upon as the harbinger of evil. The latter portent was called Helena, from the name of her who had caused the downfall of Troy, while the double flame was known as Castor and Pollux. The Christians of the middle ages replaced the names of heathen heroes and demi-gods by those of the saints. The Italian sailors hailed the light when it appeared in a stormy sea as the liberating presence of St. Erasmus of Antioch, and called it St. Ermes' fire. Modern speech has corrupted the name into St. Elmo's fire.

Many writers have described the appearance of St. Elmo's fire. Sir James Braid, returning home on horseback from Leadhills on the 20th of February, 1817, about nine in the evening, suddenly saw his horse's ears shining brightly, and at the same time the hat he was wearing appeared to be on fire. When it began to rain, the light vanished from his horse's ears, but continued on the brim of his hat until the latter was wet through. Before the rain began, numerous little sparks darted in all directions towards the horse's ears and the hat of the rider. A similar experience is recorded on the east coast of the United States, when, on a stormy night in January, 1817, several persons saw their gloves and hats, and the ears, manes, and tails of their horses, together with some brushwood and the trunks of trees on the roadside, surrounded by tremulous flames, which sent out a faint sound like the *singing* of water as it approaches boiling point. The flames were like those seen playing in the dark on the electric wires. Any kind of movement appeared to develop the flames. Thunder was heard, and rain and snow were falling together at the same time. On the 8th of May, 1831, a few officers were walking with uncovered heads during a thunderstorm on a fort in Algiers, when they suddenly noticed feathery flames resting on the points of their bristling hair. Every time that they raised their hand similar flames played about their fingers.

St. Elmo's fire is sometimes seen on the summits of towers: it was distinctly seen by Lichtenburg, in August, 1768, on St. Jacob's Tower in Göttingen. During a violent thunderstorm, accompanied by rain and hail, on the 22nd of January, 1778, Monge saw this light on many of the highest places in Rouen. Sauvan observed it for three-quarters of an hour playing round the top of St. Augustin's Tower, in Avignon. Many persons witnessed it on the 23rd of February, 1792, on the Evangelical Church at Hermannstadt. And Binon reports that for twenty-seven successive years he saw the points of the cross on the church tower of Plancet (France) fiery red during heavy thunderstorms.

Arago thought that St. Elmo's fire very frequently shone on high steeples during thunderstorms, and was not seen for the simple reason that it was not looked for. But the phenomenon does not appear to be so common as the great French physicist was pleased to imagine. We have looked for it for more than five years, in storms and thundery weather, by night and day, directing our telescope to more than a dozen steeples, most of them having lightning conductors attached, and we never once saw St. Elmo's fire upon their summits.

As to its appearance upon the masts of ships, Forbin relates that in the year 1696, during a terribly stormy night, near the Balearic Isles, he saw no less than thirty St. Elmo's fires in different parts of his ship, one of them being on one of the sails of the mainmast. "I sent up a sailor," he states, "to bring down the light. When the man reached the top of the mast, he heard a noise as if gunpowder were set on fire. As he attempted to bring it down, the light leapt on to the summit of the mast, from which place it was impossible to dislodge it, and there it remained until it gradually faded away."

An appearance resembling the St. Elmo's fire has been noticed on the surface of the sea, as shewn by the following narrative.

When James Ross and Sabine returned from the first expedition to the North Pole, and had reached the seas near Greenland, they were summoned on deck by the officer on duty during a dark night, to direct their attention to a singular track of light resting on the water exactly in the ship's course. It rose to a considerable height from the surface of the sea, which was very dark. All the crew stood watching it with amazement; and as the ship approached the light, every sail and rope could be distinctly seen. The space thus lighted up covered apparently about 1,200 feet. As the ship sailed out beyond the light, it suddenly found itself in darkness; there was no alteration or gradual diminution of light, but the phenomenon remained in its place, still shining brightly as the ship sailed into the darkness.

St. Elmo's fire is seen more frequently in winter than in summer, and especially in storms of hail and snow. It is very probable that the whole

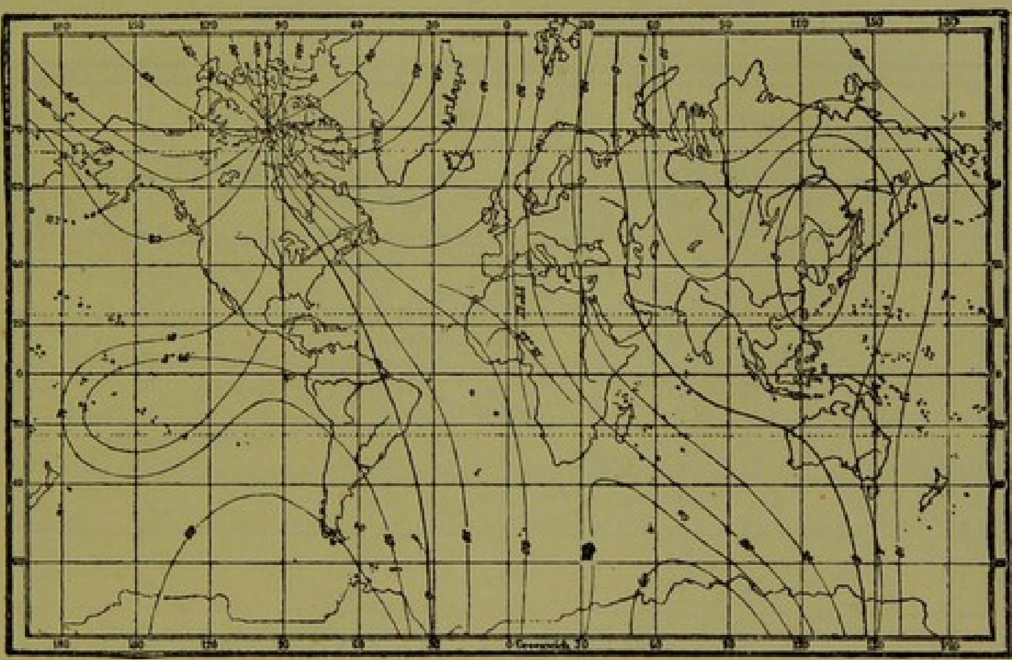


Chart of Isogonic Lines.

phenomenon is based on the uninterrupted noiseless flow of electricity from high points, especially when the electric clouds begin to break up in consequence of variable winds. It appears, as a rule, we are told by Reimarus, after a thunderstorm, and is therefore welcomed by the sailors as a sign of approaching fair weather.

Magnetic Phenomena of the Earth's Surface.

While in atmospheric electricity we find ourselves confronted by the hidden action of an universal power pervading all nature, and only revealing itself to our sight at intervals, we are forced to confess when we are met by the phenomena of terrestrial magnetism, that they baffle and evade us even more completely than is the case with the workings of electricity. Earth magnetism is as yet the most perplexing page in the book of nature. It is true that the attraction exercised upon the magnetic needle by the north was known ages ago by the Chinese; but its deviations from the true north were not perceived until about the date of the discovery of America. Later still it was found by Hartmann of Nürnberg, that a suspended horizontal bar of steel, after being magnetized by rubbing against a loadstone, inclined its northern point. The deviation of the needle from the true north is called magnetic declination, and the sinking towards the horizon is called magnetic inclination. In 1634, Hellibrand noticed that the declination at any given part of the earth's surface is not invariable, and that there was a slow yearly movement of the declination needle westward. Soon afterward the same movement was observed as to the inclination. In the year 1580 the magnetic needle in Paris pointed in a direction 11½ east of the true north; in 1663 it pointed directly north; and in 1805 it had swerved 22° westward. At the present day it has recovered its easterly movement. The inclination at the same place in the year 1671 was 75°, and in the year 1825 only 68°. These variations are not equally considerable in every part of the world, nor do they even move everywhere in the same direction. The needle is held in its place by the power of earth magnetism, and this power varies also in intensity locally

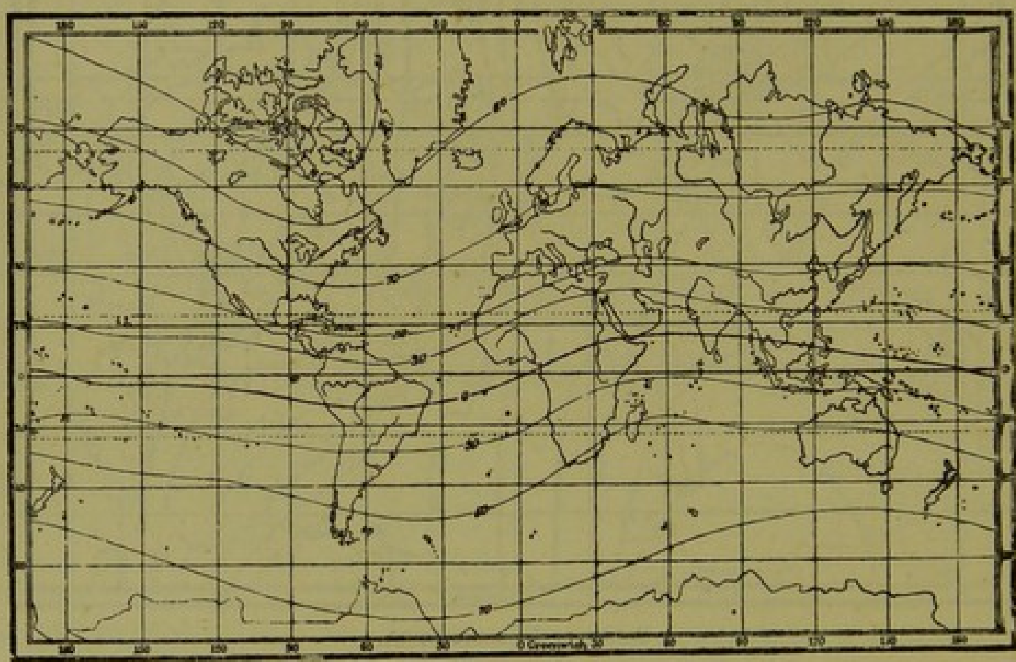


CHART OF ISOCLINIC LINES.

and from time to time. Declination, inclination, and intensity are the three magnetic properties which present us with data for estimating the distribution of terrestrial magnetism throughout the earth. As the distribution of heat and atmospheric pressure are cartographically represented, so also charts have been drawn to represent the distribution of magnetism. The lines connecting all places of equal magnetic declination are called isogonic lines, the curves of equal inclination, isoclinic lines, and those of equal intensity, isodynamic lines. Owing to the slow changes of these three properties of magnetism for each locality, the lines could only lay claim to accuracy for short periods of time. The isogonic lines converge on the earth's surface towards two points, called the magnetic poles, which do not coincide with the poles of rotation. The magnetic north pole was reached by Captain Ross on the 1st of June, 1831; it is found on the desolate peninsula of Boothia Felix.

70° 5′ north lat., and 96° 46′ west long., Greenwich. Already at a considerable distance from this spot the magnetic declination needle loses its power, and only the inclination needle points to the pole, over which it hangs vertically. The magnetic south pole, has not yet been reached; but Sir James Ross sailed so near it in his famous voyage of 1840, that the needle was only 1° removed from a vertical position. It is supposed that the magnetic south pole is found in a spot 125° east long. and 72° south lat. Between these two poles, which, as we see, are not diametrically opposite each other, there must be a line along which the needle turns neither to the north nor to the south; and this line is called the magnetic equator. The magnetic equator crosses the geographical equator in the Gulf of Guinea, and eastward of New Guinea. The points of intersection are, however, variable, and move in a westerly direction at the present time.

In examining the lines of equal magnetic intensity, it is found that there are two points in the northern hemisphere at which the magnetic intensity is greater than in the surrounding districts. One of these places is situated in

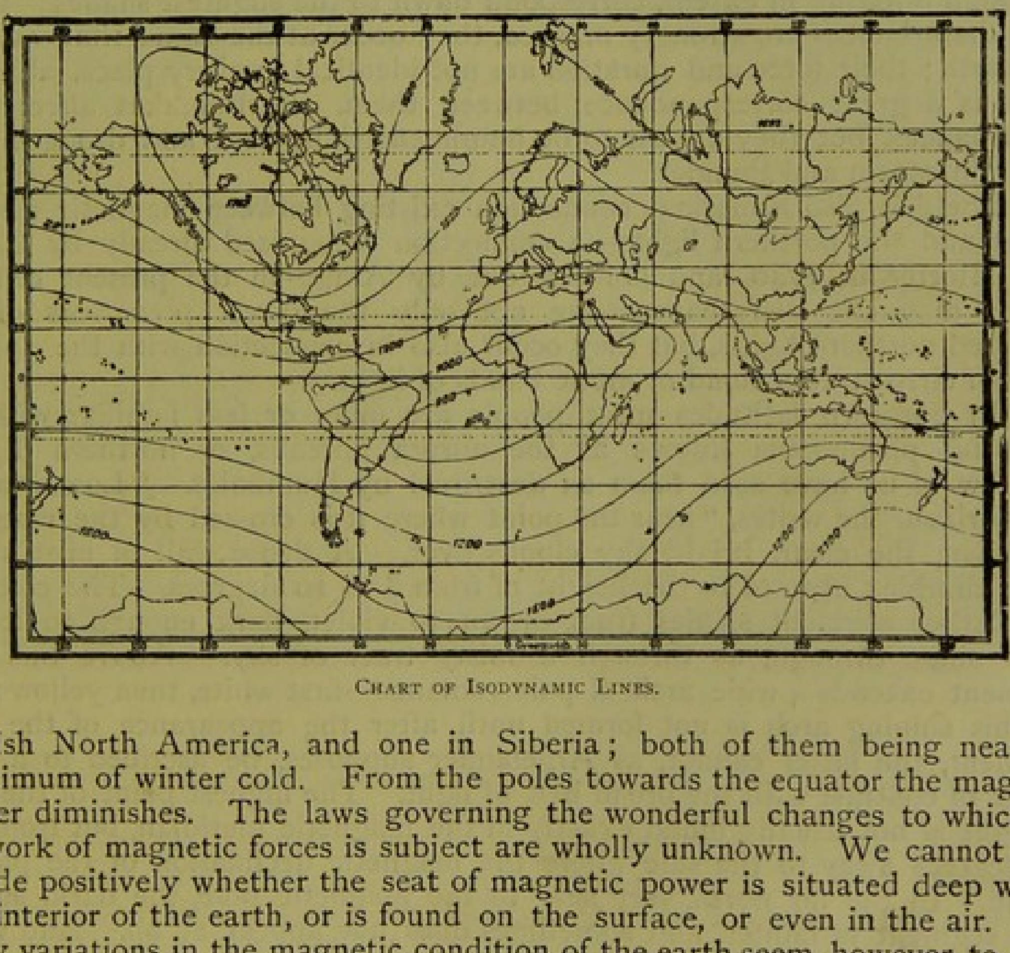


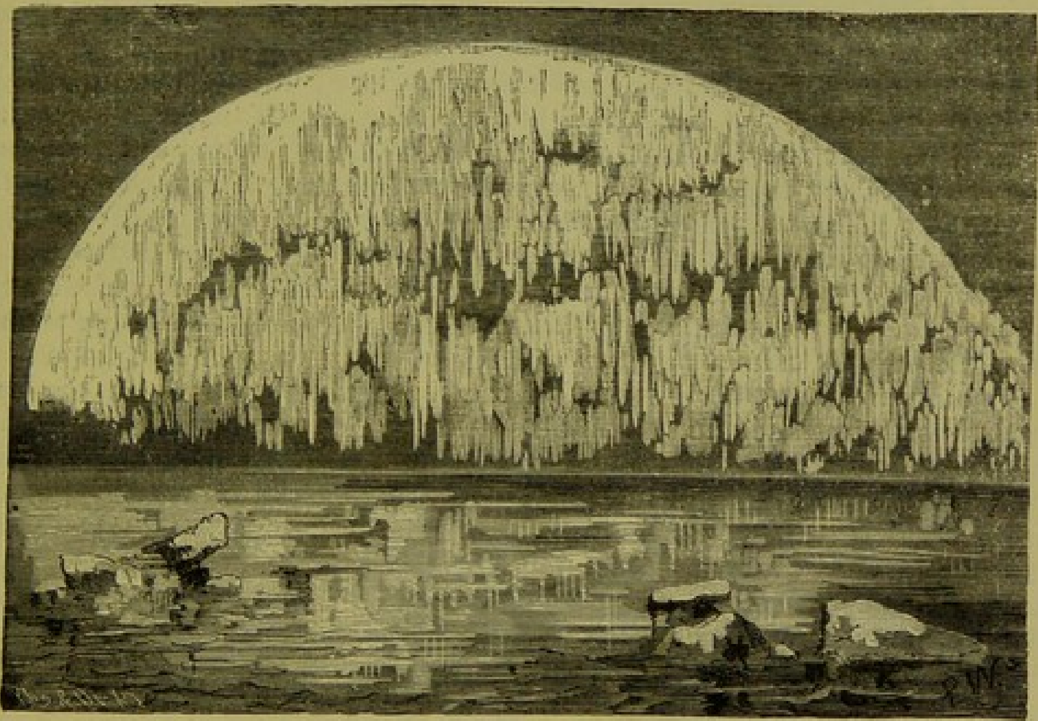
Chart of Isodynamic Lines.

British North America, and one in Siberia; both of them being near the maximum of winter cold. From the poles towards the equator the magnetic power diminishes. The laws governing the wonderful changes to which the network of magnetic forces is subject are wholly unknown. We cannot even decide positively whether the seat of magnetic power is situated deep within the interior of the earth, or is found on the surface, or even in the air. The daily variations in the magnetic condition of the earth seem, however, to point to an influence exerted by the sun's heat. With us the declination needle is stationed farthest to the east at about eight in the morning, it then moves westward till nearly two in the afternoon, after which it returns slowly and irregularly toward the east. The inclination of the needle is greatest at about ten in the morning, decreases for about twelve hours, and then increases during the same space of time. The change of intensity or total force of magnetism is similar. Weakest at ten in the morning, it slowly increases till ten in the evening, and then decreases through the night. All these movements are somewhat greater in summer than in winter, but a good instrument is required to make them perceptible. The average extent of the daily movement of the declination needle is greater in those years in which a great number of spots have been seen on the sun than in the years when fewer are observed. The moon's course is also proved to exert an influence upon magnetic variations. Under this influence the declination needle exhibits two small diurnal fluctuations dependent on the moon's transit through the meridian, and appearing analogous to the ebb and flow of the tide. These magnetic tides were discovered by Sabine, and later confirmed by Lamont. There is also believed to exist a period of magnetic intensity lasting nineteen years, and corresponding with the circuit of the moon's nodes. All these periodic movements can only be obtained as average estimates taken from a long series of careful observations; for the magnetic needle exhibits many irregular movements, which are termed magnetic disturbances. They appear at the same time at widely distant places, and, although differing in extent, correspond down to the slightest shades. When such disturbances are strongly marked, they occur at the same time over all the earth; their force and duration are not identical in every place, although there is a great correspondence between them. Earthquakes affect these disturbances, but they appear to be uninfluenced by heat and drought, cold and rain, storm and thunder.

There is also a marked connection existing between magnetic disturbances and the northern lights—a connection recognized already by Colsius and Hiorter in 1740, and pointed out by Arago in the present century. These magnetic disturbances are not only the direct precursors of the coloured northern lights, but they occur also in connection with the appearance of cirro-stratus cloud or arctic bands of light.

In our own latitudes most people are more or less familiar with the beautiful phenomena known as the aurora borealis, or northern lights; but few of us have seen them as described by Humboldt. "Low down on the horizon," he writes, "near the point where it is crossed by the magnetic meridian, the clear, bright sky clouds over. A dense wall of mist slowly rises, climbing upward to the height of from 8 to 10 degrees. The colour of the darker segment shades from brown to violet, dark enough to let the stars shine through, as through a misty tract of sky. Above this dark segment extends a wide arch of pale radiance—first white, then yellow; and as this shining arch is not formed until after the appearance of the dark segment, the latter cannot, as Argelander supposes, be ascribed to a mere effect of contrast with the broad belt of light. The highest point of the arch of light is not usually found exactly in the magnetic meridian, but from 5 to 18 degrees away to the side where the magnetic declination of the place is found. In the far north, very near to the magnetic pole, the dark, smoke-like segment is fainter, and sometimes does not appear at all. And where the horizontal power is weakest, the centre of the arch of light is farthest removed from the magnetic meridian.

"The arch of light sometimes remains for hours in constant movement and change of outline before it begins to shoot out rays and flashes of light toward the zenith. The more intense the discharges of the northern lights, the more vivid is the play of colour from violet and bluish-white through every shade to green and crimson. In ordinary electricity produced by friction the spark is colourless, until, in consequence of great expansion, the explosion is very violent. The magnetic shafts of fire soon rise alone from the arch of light, and among them are seen even columns of black rays like smoke; after awhile they rise at the same time from opposite quarters of the horizon, and rush together in a sea of quivering flames, whose splendours of light and colour surpass all powers of description, as the waves of fire pass rapidly through myriad changes of form. The vividness of the light is sometimes so great, that in January, 1876, Lovenörn saw the tremulous play of the aurora in bright sunshine. The movement of the lights add to their brightness. In the point of the arch of the sky corresponding to the direction of the dipping needle, the rays gather together, and form the so-called crown of the northern lights. It surrounds them like the cover of an aerial tent, radiant with a mild lustre, without sending forth flashes of light. It is very rare that the splendid sight is developed to the perfect formation of the crown; and when that has been once formed, the end is near. The rays become less frequent, shorter, and



THE NORTHERN LIGHTS IN THE ARCTIC REGIONS.

more colourless; the crown and bands of light are broken up. Nothing is left but irregular tracts of pale light, dim and shading to ashen grey, scattered over the sky and the dark, smoke-like segment below. At last the only trace of the glorious sight is a delicate white cloud, feathered at the edges, or broken into small round masses like the cirro-cumuli."

This description pourtrays the appearance of the ordinary northern lights of the arctic seas; but there are other special forms of the phenomenon seen in northern latitudes. In the Austro-Hungarian arctic expedition of 1872-74, Weyprecht saw numerous polar lights, and carefully observed their changes of form and colour. "At first," he tells us, "appears a faint arch of light, growing clearer as it rises toward the zenith. It seems composed of a delicate white aerial substance, tinged with pale green. The moonlight appeared a vivid yellow under its light. The arch is sharply outlined at the edges, and appears about three times as large as a rainbow. It rises higher and higher, the whole vision having an air of absolute repose, except for the occasional slow, silent passage of a cloud of light from one side to the other. Before the first arch has reached the zenith, another and another rise from the dark segment on the horizon. All ascend slowly to the zenith, and then descend with gradually diminished lustre toward the horizon. Sometimes they turn back from the horizon, fading away as they came." At other times Weyprecht saw the northern lights in the form of a belt of light continually changing its place and shape, while waves of light played continually throughout its whole extent. Sometimes the belt was formed of separate rays close together, and extending parallel in the direction of the magnetic pole. It happens sometimes that the whole sky is covered with these streams of fire, or that only a few sheaves of light are to be seen, remaining unchanged for hours together. Another picture is given as follows: "A storm is just sinking to a calm; below, upon the surface of the ice, the wind has died away, but the flying clouds shew that it is raging furiously overhead. A pale light falls on the ice, the aurora is playing behind the clouds, shining through the thin veil, and softening the gloom of the stormy night. A quiet star shines here and there, and through the spaces between the clouds the lights are seen darting on their wild chase toward the north. The clouds grow thinner, and fly like balls of mist before the wind. Fragments of broken lights are seen on all sides; it seems as if the storm had torn the vivid streamers to rags, and was hunting them across the restless sky. They appear and disappear with lightning speed, changing form and place at every moment; a flash shines now here, now there; it is lost; again it rises in another quarter of the heavens. The light waves rise and fall through every torn and broken fragment; at one moment they fade, at the next they brighten into intense brilliancy. But they shine no longer with the pure white light of calmer nights; a dusky yellow, half light, half vapour, fills the sky; it is difficult to distinguish the lights themselves from the vague shining mists that rise and fall on all sides." One more description from the same pen: "All day long the sky has been crossed by bands of light of every possible shape and degree of intensity. It is eight o'clock in the evening, the hour of the greatest vividness for the northern lights. For awhile only isolated sheaves of rays are seen above us, and yonder, in the south, a faint, almost imperceptible band resting upon the horizon. All at once it rises rapidly, and spreads out eastward and westward. The waves of light begin their tremulous play, and upward flashes dart toward the north. For a short time it remains stationary, and then breaks out into sudden life. The waves of light dart from east to west, the edges assume brilliant red and green colours, and dart up and down. The fiery rays flash faster and faster as they come nearer to the magnetic pole. Quicker and quicker the chase continues, wave gaining on wave, crossing and overleaping each other in the wild rush to be first at the goal. No longer in isolated rays, but in sheaves and clusters of flames, they fly upward along the southern sky. Now they reach the point to which they were hasting, and one and all are scattered far and wide, north, south, east, and west. Are the rays rising or falling? Who can tell? They are all of three colours, red, white, and green, a central sea of quivering flame, with darting rays reaching to the horizon; the whole heavens are on fire. The band has changed to an arch spanning the pole, and resting on the horizon; it changes to a stormy river of flame, where the fiery current rushes from side to side with dizzy speed. Nature is exhibiting such a display of fireworks as transcends the boldest dreams of the imagination. It seems impossible that these flashes and streams should rise and burst without sound. We listen for the crash of an explosion, and are met by perfect stillness, absolute soundless silence. The ice is clearly outlined by the light; every point and jag is brought into sharp relief, and the distant line of the horizon shews black against the white frozen plain. The peaks cast shadows on the surface. The smallest print can be read with ease. But only for a time. As rapidly as it came the whole pageant fades. Only along the northern horizon stretches a band over which the dying light waves flicker. The ice is veiled again in night and darkness. Such is the northern light that tells of coming storm; the aurora in its fullest glory. No words can describe, no brush can paint, the splendour and beauty of the sight."

THE NORTHERN LIGHTS IN NORTH AMERICA.

These manifold and beautiful phenomena of the northern lights are only seen in the far north, where the true home of the aurora borealis lies, in the arctic circle itself. The displays are most frequent, as has been proved by the valuable researches of Fritz, in the ice boundary of the Arctic Sea:—

"Let us begin our researches," he writes, "in Europe. As we move eastward round the pole, we find the well-known fact confirmed in our own continent, that the direction of brightest light (visibility) generally corresponds with the direction of the magnetic meridian. No deviation is noticed until we reach high latitudes, and approach Asia. From the White Sea to the islands of New Siberia, the direction divides in two courses, so that throughout the whole of Siberia we have the northern lights, sometimes to the north-west, sometimes to the north-east of the meridian; the variations from the magnetic meridian, and the differences of form, colour, and intensity in the lights themselves, being very considerable. The western lights rise in arches, while the eastern aurora is brighter, and darts out rays of much greater intensity and beauty of colour. From the islands of New Siberia, across Nischnei, Kolymsk, and Behring's Straits to Barrow Point, the lights appear always near to the true north. From Barrow Point back again to Europe, the directions of the countries north of 50° latitude change so decidedly, that it is scarcely right to say that any particular direction exists. In the neighbourhood of Bear's Lake, Fort Reliance, Fort Enterprise, Fort Confidence, etc., we see the direction sometimes close to the true meridian, sometimes near the magnetic meridian, sometimes in a rectangular position from one or the other; farther northward, as in Winter Harbour, the light appears in the south, and this direction is maintained between the magnetic pole and the northern limits of the Arctic archipelago (as far as it has been explored), across to the coast of Greenland and the northern boundary of Hudson's Bay. There are, however, considerable deviations of direction; for while in Winter Harbour the direction is southward, and almost parallel to the meridian, passing to the west of the magnetic pole, it appears in the districts between Melville Sound, Wellington Channel, Lancaster Sound, M'Clintock Sound, and the Gulf of Boothia, sometimes directly towards the magnetic pole, and sometimes to the right or left of it. In Hudson's Bay it is found in every quarter of the sky. In Baffin's Bay the direction is in the north; in about 70° latitude it is south-easterly, and remains so, generally speaking, through Davies' Straits and along the coasts of Greenland to its southern extremity. Some observers report that the direction in this place is southward; others, that it is rather westerly; and others again, especially in Labrador, that it changes from one quarter of the sky to another indifferently. This changeableness of direction is also noticed farther eastward, in the northern parts of the Atlantic Ocean, as has been proved by the careful observations of many sailors. Scoresby saw the northern lights in 1822 shining from the north when in 65° and 5° western longitude; the arches rising to the zenith, and extending from north to south. Between latitudes 60° and 59°, and longitudes 50° and 26° west, Parry, Ross, Robertson, and others saw them sometimes in the north, sometimes in the north-west, sometimes in the north-east, and sometimes spreading over the whole sky. In 1746, latitude 38° and 49° west, they were generally seen in the south-east to the east; while in 1859, in the same latitude, M'Clintock saw them in the north-east. In 1820, Parry saw the light in latitude 57°, and in 45° west longitude, shining in the south. Not until 55° latitude does the direction seem to be constant in the north quarter. In the most northern point that has yet been observed, namely, in Renszelaer Harbour, in Smith's Sound, which connects Baffin's Bay with the northern seas, Kane saw the lights in two different directions, south-west, and north-north-east.

In America, below latitude 50°, and in the South Atlantic Ocean, the direction deviates but little from the north; and as the magnetic deviation is slight in the United States, the direction of visibility nearly corresponds as it does in Europe with the true magnetic meridian.

The arch of the northern lights is generally seen in Europe only in the northern parts, especially in Scandinavia; in Asia it is seen only in the eastern parts of Siberia, rarely near Behring's Straits. It is much more frequently observed from Barrow Point, the displays becoming more frequent near Hudson's Bay, and sometimes it is seen near Cumberland House, and even in lower latitudes. The northern lights seldom shine from the north in arctic America or the west coast of Greenland; or if they do so, the light is generally dim. In Iceland the direction is entirely northern.

The aurora australis, or southern lights, are similar phenomena observed in the antarctic circle.

As there are places where the nights are often brightened by the flashes of coloured polar lights; as, for instance, the north-western parts of America, Lapland, and the Shetland Isles; there are also years in which these displays are intense and frequent, and others in which they are weak or altogether absent.

Fritz has collected a mass of evidence as to the frequency of the displays in certain years. He comes to the conclusion that in Europe the lights are a periodic phenomenon, completing their course in $55\frac{3}{5}$ years; that each of these longer periods is broken up into shorter periods of $11\frac{1}{9}$ years; that the northern lights are closely connected with the formation of spots on the sun's face, the years of greatest frequency being those when the sun's spots are most richly developed, and *vice versâ.*

Besides the periods above mentioned, the northern lights have also an annual period of frequency. They are most frequent at the times of the equinox, and least frequent at the solstices. Loomis gives the following distribution through the different seasons of the year: Spring, 698; summer, 661; autumn, 744; winter, 542. In this classification the yearly frequency does not appear so striking as it really is; it is more readily seen when the frequency for every month is given. The northern lights are closely connected with the cirri, or feathery clouds of the upper atmospheric strata; they generally announce themselves by means of meteorological processes in the highest regions of the air. Masses of fleecy cirrus cloud, or the so-called "polar bands," are formed, and the magnetic instruments betray more or less disturbance. These polar bands are singular formations; they shine in moonless or starless nights, with a phosphorescent gleam, and are considered to be the first and most general indication of a high state of activity in the force known as earth magnetism.

As to the height of the polar lights above the earth, opinions differ. Those who have studied the phenomena in the north maintain that their home is found in our ordinary cloud strata; in Norway it is thought that the lights settle down on mountain peaks like a mist swept by the wind. This popular notion is supported by the observations of Lemström, who often saw shining mists on the mountain heights in 79° 39′ north lat., and 11° east long. These mists sent out flashes like the rays of the true aurora borealis. Be that as it may, the displays referred to must have been very faint, for no lights were observed on the days mentioned, either in North Germany, Sweden, or the Russian provinces of the Baltic. But when we mean by the northern lights those grand phenomena of the far north, which send out rays of coloured fire over a surface of 100,000 square miles, we find that they shine at an immense height above the surface of the earth; for if the position of a ray or an arch of the aurora is determined by observations taken at several places situated sufficiently far apart, it is possible to calculate the height of the phenomenon by mathematical processes; and wherever such calculations have been made, the height has been found to extend to several miles.

A display of the aurora borealis, seen on the 25th of October, 1870, was accurately examined by Flögel. At a quarter-past six the rays had only extended over the Netherlands, Hanover, and Mecklenburg, but between a quarter to seven and a quarter to eight they developed to grand proportions; and embraced at least the south of England, Belgium, Westphalia, North Germany, and Poland, as far as central Russia. The vertical height of the rays reached from 280 to 320 miles. During the display an arch of an intensely red colour was seen at different places across the sky, which appeared to have no direct communication with the rays. This arch looked like a fragment of a circle of red light turned up at its southern edge. The observers in the south saw the circle from the broad side, and those in the north from the narrow. Flögel says that the observations agree satisfactorily if the height of the southern edge is taken as from 280 to 320 miles, the northern edge as 160 to 200, the breadth as 120 to 160, the vertical width as sixty miles, and the inclination toward the horizon as 35°.

Science is yet unable to give a decisive explanation of the origin of the northern lights. Contrary to former views, it is now believed that they are affected by the action of earth-electricity.

The earth, broadly speaking, may be looked upon as a magnet, the axis of which forms an angle with the polar axis. Under these circumstances, a strong ascending current of positive electricity must take place on the earth at the equator, gradually diminishing in intensity toward the poles. At the same time an outflow of the electric fluid must move toward the poles, where the electric density is greatest within a circle surrounding the magnetic and geographical pole. The positive electricity of the equatorial zone can only descend to the earth's surface again in low latitudes, either when the air by its great moisture becomes a better conductor, or when the electric fluid in wide masses of cloud condenses very near to the earth's surface, and produces the disruptive discharges of thunderstorms. The electricity which is not restored to equilibrium by this means rises in the air toward the pole, and flows on in continuous streams toward the earth. These streams, which travel through the thin strata of the atmosphere, are the northern lights. The difference in the method of electrical discharge in high and low latitudes is determined by the influence of earth magnetism on the moving electric particles. Generally speaking, therefore, the periods of frequency of the northern lights will be exactly opposite to those of thunderstorms. On the other hand, the electric currents must affect the magnetic needle on the earth's surface, and as they increase or decrease in strength, so creating the peculiar tremulous flicker of the aurora, they occasion also the fluctuations of the magnetic needle. These fluctuations may, on the other hand, indicate polar lights, which are not directly visible.

Wijkander tells us that the sky at night is never so dark in the Arctic regions as it is with us; it has generally a grey colour, such as is frequently noticed in Norway and Sweden. This appearance is perhaps caused by weak electric currents continually passing through the air. Perhaps certain phenomena sometimes seen in thunderstorms form a kind of transition process to northern lights. In July, 1868, Decharme relates that during a thunderstorm flashes of phosphoric light played over whole masses of cloud; and as the storm drew nearer were accompanied by a bluish-white radiance, which came in waves through the open window of the room. On the 25th of July, 1877, during a storm in the south of Sweden, a tremulous mass of red light was seen hovering over a little inland lake. It was indisputably a light vapour such as is seen in the northern seas. Similar lighted mists shone round it as the storm continued, but only lasted for a few seconds.

THE NORTHERN LIGHTS.

Bourbon Palm (Latania Borbonica.)

LAND, SEA, AND SKY.

PART THE SECOND.

CHAPTER I.

THE ORIGIN OF ORGANIC LIFE.

IN passing on to the second part of our subject, which embraces a general *résumé* of the distribution of animals and plants, sketches of animal life, and particulars of the various uses to which the animal and vegetable world are turned by the dominant race of men, it will be frequently necessary to call in the testimony of travellers and explorers, whose writings bring vividly before our eyes the scenes through which they have wandered. But the traveller, as he passes on his adventurous way, has far other things in his mind than the general instruction and interest of the public for whom we are writing; at least, the present writer has read carefully through many large volumes of travels, in which he has found scarcely anything accurate and to the purpose concerning the animal and vegetable life of the countries visited. Any striking occurrence or unusual sight is narrated, but no clear, definite picture of the local flora and fauna is given.

To paint such a picture the traveller must, as Schweinfurth says, be also a botanist and geologist, or else he runs great risk of giving a faultless, almost classical description of the primeval forest, without remembering to say of what kind of trees it is composed.

Thrilling stories of the chase, which create a half-incredulous wonder, and tales of exciting adventure by flood and field, would perhaps be welcomed by some readers, but they are altogether out of place in a book like this, which endeavours to present a faithful picture of the organic life of the earth; indeed, it will be our mission to dispel many a current and popular illusion which has lived too long in the credulous fancy of the uninitiated, and may even linger in the mind of some of our present readers. We will therefore preface our enquiry into the origin of organic life by an exposure of two popular fallacies.

And first, as to the desert of Sahara. "A boundless sea of shifting sand surrounds the caravan, escaped with difficulty from the burning desert wind, the chamsin, or simoom, which threatened its destruction. As far as the eye can reach, nothing meets its gaze but scorching sand and a burning sky. Then come chains of sandhills, and these dreaded dunes of drift-sand, which reach to the height of 140 yards along the coast of the Atlantic Ocean, and even force their way out into the sea, building up mighty sandbanks, testing the patience and endurance of man and beast to their utmost limit. Wearily the traveller climbs up the treacherous sandy height, and sees from its summit chain after chain of similar obstacles to be surmounted. The path which seems to offer the shortest way is carefully examined, to see whether, as is sometimes the case, the sand will bear. But the camel sinks deep in the yielding soil, and perhaps, when the crest is at length gained with indescribable difficulty, the descent on the other side may be so precipitous, that the unwieldy animal is unable to keep his balance, and either falls himself, or throws down his load in the sand. Very often he has to be unloaded, and the rider is forced to drag down the separate articles of the load one by one to the foot of the sandhill, through the merciless heat. The path leads on in endless zigzag and unrelieved monotony. Hoping against hope, the wanderer looks from every height to find some less wearisome track, some change from the endless up and down of the sandhills. The wearied eye searches the horizon, and sees nothing but the next chain of sandhills; exhausted, almost despairing, he climbs to the summit of the next; still hoping, and still doomed to disappointment. If the day is bright and clear, the dazzled eye turns smarting and inflamed from the glaring surface of the sand, which throws up quivering rays of heat; if the wind blows, the traveller is enveloped in an atmosphere denser than a London fog or a Dutch mist, and dares scarcely raise his burning eyelids. All interest in the strange scenery, all the overpowering impression of the sandy ocean, which rivals even the sea itself in grandeur, and surpasses it in its majestic stillness, is gradually blunted and worn away in the struggle with nature. It is in difficulties like these that the value of the camel is learnt and recognised; that it is owned to be in truth the 'ship of the desert,' appearing now upon the crest of the sandy hill, and now lost to sight in the deep valley. Without its aid the desert of Sahara would be inaccessible to man. There is nothing resembling a path or tract across the chaos of sand-heaps, and even the keen eyes of travellers accustomed to the desert fail to discern any sign which may serve them for a guide. The only pillars of refuge are the rare fragments of rock which have withstood the attacks of the sand for thousands of years, and stand stark and forbidding above the changing, shifting ocean at their base." We have all read in our young days descriptions like the above, and have, perhaps, worked them out in our imagination, filling up the outlines, and adding colour to the sketch, until the picture of the desert was fixed upon our mind. And yet, as Nachtigal tells us, such a picture is only true of the typical desert, as it is found in rare and isolated places, where it certainly taxes to the uttermost the skill and endurance of both man and beast. Sometimes it extends over tracts of considerable extent; the traveller has to fight through its difficulties for five or six days together along a stretch of about a hundred miles. But fortunately the desert of Sahara has other pictures to present to us. We find within its boundaries rocky and gravelly soil, and instead of the long rolling waves of the sandhills, we meet with the welcome alternations of hill and dale, which, as we shall shew later on, are not wholly destitute of animal and vegetable life.

The second fallacy we have to refute is that which imagines that the vegetation of the tropics is always and everywhere gorgeous in colour and luxuriant in blossom. The country is supposed to be covered with primeval forests of giant trees and graceful palms, with a profusion of splendid flowers and large shrubs covered with masses of coloured blooms. Seldom, indeed, is the picture of the imagination realized in sober fact. Wallace confutes the popular belief in several of his works. He tells us that his travels through the tropical lands of the east and west have convinced him that flowers are, on the whole, more numerous and more strikingly beautiful in the temperate zones than in the most luxuriant regions of the tropics. The brilliant masses of colour which lend such brightness and charm to the landscape, even in England, are never seen to such advantage in the tropics. The broom-covered meadows, the hillsides clad in crimson heather, the pasture lands with their wealth of wild hyacinths, the fields and meadows, bright with scarlet poppies, buttercups, and orchids, weave their carpet of purple and gold, sky blue and fiery red, such as tropical lands seldom have to shew. And for smaller masses of colour we have our hedgerows of white and pink hawthorn, our wild apple trees, our mountain ashes, foxgloves, primroses and purple vetch, covering the length and breadth of the land with their brilliant hues. The beautiful blossoms are found everywhere; they are characteristic of our country, and have not to be sought for in scattered nooks and corners, but gladden the eye at every turn. In equatorial lands, on the contrary, a sombre green covers the land, both in the forest and the savannah. The traveller can pursue his journey for days together without meeting anything to relieve the monotony. Flowers are everywhere very rare, and only at long intervals is the attention claimed by anything of special interest. It is easy to understand how the false idea of tropical nature has arisen. In our conservatories and flower shows we collect the most beautiful flowering plants from every quarter of the globe, and place them near to each other, in such a manner as they never assume in nature. Hundreds of different plants, all of them adorned with brilliant leaves or strange and gorgeous flowers, present a magnificent spectacle of bloom and colour; but perhaps no two of these plants are ever seen together in nature, because one of them may belong to some different country, or grow upon a different soil. Moreover, all the temperate climates out of Europe are claimed for the tropics. There seems to be a vague idea that everything especially beautiful *must* come from the hottest parts of the earth. But facts directly contradict this supposition. Rhododendrons and azaleas are plants belonging to the temperate zones, the most beautiful lilies come from Japan, and a great number of our most admired plants have their home in the Himalayas, at the Cape, in the United States, in Chili, or in China and Japan, all districts situated within the temperate zone. It is true, doubtless, that there are a great number of brilliant and gorgeous flowers to be found within the tropics, but the colour which they contribute to the whole mass of vegetation is very insignificant, so that, notwithstanding the apparent anomaly, the fact remains that the effect of flowers is far greater in extent and vividness in temperate lands than in the equatorial districts.

Again, an idea of tropical nature formed from the contemplation of our best conservatories and forcing houses will lead us astray in another point. All that we see before us in the conservatory are highly, nay, perhaps over-cultivated, specimens of their kind. Scarcely does a leaf begin to change colour before the gardener is careful to remove it as a disfigurement, and we are unconsciously led to think that nature will condescend to play the gardener's part, instead of bearing patiently with the fading growth for years together. A splendid plant of the winter garden is the Bourbon palm (*Latania borbonica*), but who would recognise it with its magnificent fan-shaped leaves in our—shall we say unfortunately faithful illustration? We must make up our minds to take for granted that the tropical plants sent for European inspection are almost always idealised specimens, faultless and carefully selected, while the very reverse is true of the pictures of animal life submitted to our notice. Very few artists possess the gift of rendering a faithful portraiture of living animals, and drawings made, as is so often the case, from stuffed beasts and birds suffer from the mistakes of the taxidermist during his preparatory work, mistakes which are, as a rule, neither few nor slight.

We have then, on the authority of two experienced travellers, refuted two popularly received errors, and we shall have to return more than once to this part of our subject. As to the old nursery stories, such as tell of the traveller in the desert slaying his camel in order to quench his thirst with the store of water found in the animal's stomach, we shall pass them over with well-deserved silence.

On the threshold of our subject, which leads us from the examination of our world as a globe made up of land and water, and surrounded by air, to the closer study of the organic life upon its surface, we remember Humboldt's words upon a kindred theme. "When man investigates nature," he says, "or measures in imagination the boundless tracts of organic creation, none among all the manifold impressions of which he is conscious acts upon him so profoundly as that produced by the universal fulness of life. Everywhere, even in the neighbourhood of the ice-girt poles, the air is vocal with the song of birds and the hum of myriad insects. It is not only the lower strata, heavy with mist and vapour, but even the higher etherialised air is teeming with life. For as often as we ascend the chain of the Peruvian Cordilleras, or ascend the summit of Mont Blanc south of the Lake of Geneva, we find the solitudes peopled with living creatures. On Mount Chimborazo, almost 8,200 feet higher than Etna, butterflies and other winged insects are seen. Even though they wander in those high regions like travellers gone astray, having been borne upward by some strong vertical current, yet their very presence proves that the more pliant animal creation can exist where the vegetable kingdom has long since reached its limits, and whither man himself forced his way with difficulty, spurred on along his perilous path by the desire for knowledge. Higher than the conical peak of Teneriffe, placed upon the snowy ridge of the Pyrenees, higher than any peak of the great Andes chain, the giant condor flutters overhead, allured upward by the desire for prey and the sight of the fine delicately fleeced vicunas which roam the grassy plains in herds."

But if the air reveals its stores of life to the unaided eye, how much more has it not to shew to the eye armed with the microscope! If our path lies through the woods, we find the trunks of the trees, especially on the weather side, covered with a coloured growth, sometimes green, sometimes grey, which the finger can wipe away in a moment. If we go on toward the marshy waters, whose surface and brink serve as the dwelling for countless species, we see upon the soil the mouldering remains of plants often coated with a brown, red, yellow, or earthy colour; now let us bring these variegated masses under a suitable microscope, and we shall very seldom find them to be really inanimate deposits, or even the meanest children of the great mother. As a rule, they are made up of comparatively highly organised beings, which arouse the admiration and delight of the explorer, and teach him to guess dimly at the laws which nature obeys in the development and creation of organisms. All these microscopic creatures, be they plants or animals, will only be mentioned here slightly, and by exception, because they do not affect the character of the landscape as it should be described in a manual of physical geography, and the same may be said of the minute living organisms which may be discovered around us even by the eye unaided by a microscope. Our attention will be principally directed to mammals and birds, and the most characteristic plants of different lands. It is, however, uncertain whether life is more widely developed on land or in the seas and their tributary waters, and some of our space must therefore be devoted to the inhabitants of the ocean and its rivers and streams.

Even the uninitiated, who has not made the flora and fauna of the world a subject of close study, knows that it is not every kind of plant or animal which can exist in every quarter of the globe. He knows that the tropics can never be the home of the polar bear, and if asked why bears are not found near the equator, will readily give the answer, which is true as far as it goes, that it is too warm for them there, and that they would not be able to find necessary and fitting nourishment—in short, that the conditions of their existence do not exist in the tropics. But the geographer of the animal and vegetable kingdom must not be content with obvious cases like the one just mentioned. He finds that there are an immense number of animals and plants which are not found in places where there is every apparent requisite for their growth and well-being. He asks himself why there are no wild ruminants in Australia, such as are found in every other continent, while there are at least fifty million sheep and nearly seven million oxen; and why it was reserved for Lucullus, the victor of Mithridates, to be the first to bring us the best and most enduring of his victorious spoils, the cherry tree, from Asia Minor into Europe.

In reference to the latter question, we must say that many animals and plants are not found in places adapted for their existence, either because they have not been naturally produced, or artificially transplanted there, or because they have fallen as victims to unfavourable circumstances or the attacks of their enemies. This leads us to a general consideration of the process of development through which both animal and vegetable life have passed in the course of ages.

Many reasons, which we have stated in the early chapters of this work, have led to the conclusion that the earth was formerly a ball of heated gas, and afterwards a body of liquid fire. During the slow process of cooling down, the heat was sent out by radiation, the globe was at length surrounded by a crust strong enough to become the home of organic life. It follows, then, that there must have been a beginning of animal and vegetable life upon the earth, and that they could not have existed upon it from eternity. This conclusion is supported by the evidence of the earth itself; for if we examine more closely the ground on which we tread, we find it composed of a mass of rock underlying thousands of earth and rocky strata. The lowest of the earth strata are the oldest; the youngest and highest are in process of formation before our very eyes, brought down and spread abroad by the deposits of rivers and seas. Each stratum contains within it the fossil remains of plants and animals, and lies beneath us like a book in which our mother-earth has written her own life history; and as, in the history of races and kingdoms, we divide our periods into prehistoric time, and ancient, mediæval, modern, and contemporary history, so do the silent records of the rocks enable us to divide the history of the globe into different ages.

The oldest rocks of the earth's crust are *azoic;* that is, they contain no organic remains recognisable as such. It by no means follows, however, that at the time when these rocks were formed, there were no plants or animals in existence; on the contrary, it is stated by the best authorities that the graphite contained in crystalline slates represent the last remains of the oldest vegetable life. It may be a matter of little importance to us at what precise moment the first living creature saw the light of this world; others may speculate as to whether that first dawn of vegetable and animal life brightened millions or myriads of years ago, whether our Creator imparted life to lifeless matter by a word, or by the slow, silent action of cosmical forces: enough that at a moment unknown to us life sprang into being upon our earth. But this life was not clad in vegetable and animal forms such as we now see around us; perhaps not in forms which we could recognise as belonging to either of the two kingdoms. The first living forms were probably those mysterious creatures known as protozoa, which may serve as starting points for the development of vegetable or animal formation.

Beginning, then, with the lowest strata of the earth, and examining every layer, from the oldest to the most recent, we find a number of floras and faunas gradually changing in form, so gradually indeed that we are unable to determine the exact period at which one ceases and the next begins. Every kind of plant or animal fossil is limited to a certain part of the earth's strata, being found neither above nor below a definite level. The lower strata contain only fossilized forms, which are now utterly extinct, and the higher we ascend the more we find these lost types accompanied by fossils of living forms, until we reach the strata still in process of formation, which contain only fossils of living forms.

The strata of the earth's crust, and the organic remains preserved within them, are classified into formations and sub-formations, according to the composition of the rock and the fossils it contains. The following table gives a short summary of this classfication; among the animals and vegetables we have only mentioned those which are best known or specially abundant, or which deserve to be recorded as types of a new formation :—

FIRST AGE OF THE WORLD. ARCHAIC PERIOD.

This age is *azoic;* that is, the rocks which belong to the period contain no organic remains recognizable as such.

SECOND AGE OF THE WORLD. PRIMARY OR PALÆOZOIC PERIOD.

I. Silurian Formation. Old Transition Rock.

	ANIMALS.	PLANTS.
a. Cambrian strata . .	Traces of worms. . .	Oldhamia antiqua, the earliest undoubtedly organic fossil, allied to the polyzoa or serbularidæ; compound polyp animals.
b. Strata with primeval fauna.	Trilobites, primeval crab, brachiopods.	Sea grass.
c. Strata with lower silurian fauna.	Trilobites, brachiopods, first appearance of cephalopods.	
d. Upper silurian fauna .	Trilobites, crabs, cephalopods, brachiopods, starfish, corals, along the upper boundary lines the first fishes.	

II. Devonian Formation. Latest Transition, or Grey Sandstone Rocks.

a. Shales . . . . *b.* Old red sandstone . *c.* Lower limestone shale .	Corals, sea lillies, brachiopods, shell fish, trilobites.	Sea grass, the first land plants, especially cryptogamia and earth moss, the first pine.

III. Carboniferous Formation.

a. Carboniferous limestone .	Disappearance of trilobites, reef-forming corals, starfish, molluscs (productæ).	Reeds (*calamites*), ferns, mosses, wolf's foot (*lepidodendron*).
b. Coral beds . . .	Molluscs, crustaceæ, fish.	Calamites, ferns, mosses (*lepidodendron*), and sigillaria, annularia, coniferæ cycadaceæ.

IV. Dias or Permian Formation.

a. Lower red sandstone .	Insects, fishes, first reptiles (*archegosaurus*).	Tree ferns, coniferæ, palms (fossilized forests).
b. Magnesian limestone .	Corals, sea lilies, brachiopods, mussels, heterocereal (irregular tailed) bony pike.	Grasses, ferns, coniferæ.

THIRD AGE OF THE WORLD.

V. Trias Formation.

	ANIMALS.	PLANTS.
a. Variegated sandstone .	Corals, molluscs, crustaceæ, footprints of saurian frogs.	Calamites, ferns, coniferæ, and a few monocotyledonous plants.
b. Shell limestone . .	Sea lilies, brachiopods, cephalopods (*ceratites nautilus*), snails, mussels, the first long-tailed crabs, sea-lizards (*nothosaurus*), fishes.	
c. Keuper (marls and sandstones).	Brachiopods, mussels, shell-crabs, saurian frogs (*mastodon-saurus*), crocodile (*belodon*).	Calamites, equisetites (horse-tails),ferns, pines (*voltzia*), coniferæ.

Carboniferious Flora.

a. Stigmaria and ferns. *b.* Calamites. *c.* Lepidodendron. *d.* Sigillaria. *e.* Tree fern.

BOUNDARY STRATA BETWEEN TRIAS AND JURASSIC FORMATIONS.

	ANIMALS.	PLANTS.
Bonebed	Molluscs, especially mussels (*avicula*), fishes, lizards, first remains of mammals (teeth of a marsupial, microlutes).	Calamites, ferns, pines, coniferæ.

VI. JURA FORMATION. OOLITE ROCKS, PLANTS.

	ANIMALS.	PLANTS.
a. Lias (black jura) . .	Sea lilies (pentacrinus), molluscs (ammonites and belemnites), fishes, sea saurians (ichthyosaurus and plesiosaurus).	Few sea weeds, calamites, ferns, coniferæ, pines.
b. Middle oolites (Oxford clay).	Fishes, megalosaurus, marsupials, reptiles.	
c. White jura (malm or firestone.	Many sponges and reef-building corals, sea lilies, molluscs, worms, first vertebrate fish, tortoises, flying lizard (pterodactylus), oldest remains of bird (archæopteryx).	Rare.

Boundary Strata between Jurassic and Chalk Formation.

	ANIMALS.	PLANTS.
Forest clay formation . .	Snails, mussels, crustacea, fishes, giant saurians (*iguanodon*).	Calamites, ferns, marsiliaceæ, coniferæ.

VII. CHALK FORMATION. FREESTONE. ROCKS.

a. Neocomian rocks . .	Toxaster, brachiopods, mussels, cephalopods.	Ferns, palms, pines.
b. Gault (upper or chalk division).	Foraminiferæ, brachiopods, mussels, cephalopods.	Sea weed, ferns, coniferæ, pines, and one monocotyledon.
c. Hastings sand . . .	Sponges, foraminiferæ, corals, star-fish, crustacea, worms, crabs, fishes, lizard of the Meuse (*Mosasaurus*).	Sea weed, ferns, few coniferæ, more pines, palms, the first dicotyledons (more than 200), with numerous large-leaved trees.

Fourth Age of the World. Cainozoic Period.

VIII. EOCENE FORMATION. SANDS, CLAYS, AND MARL.

	ANIMALS.	PLANTS.
a. Lower eocene . . .		Sea weed (*chondrites*). In central Europe a genuine tropical flora of Indo-Australian habitus.
b. Upper eocene . . .	Nummulites, first great mammal fauna (*Palaeotherium*, *anoplotherium*, *xiphodon*, etc.). No ruminants at first. Ungulata, proboscidians, edentata, insect eaters, and apes. To this period belongs amber, with its many insect enclosures.	

IX. Neogen, or Later Tertiary Formation.

	Animals.	Plants.
a. Miocene	Second great mammal fauna (*Mastodon*, *dinotherium*), horse, hipparion, cats, hyenas, dogs, apes, etc.	In central Europe, forests of tropical and sub-tropical character; retreat of New Holland types, and prevalence of American.
b Pliocene		In central Europe, disappearance of palms, acacias, and mimosas. Greater abundance of willows, poplars, and maple.

Fifth Age of the World. Present Time. Anthropozoic Age.

X. Diluvium. First Quartiary Formation.

XI. Alluvium. Later Quartiary Formation.

	Animals.	Plants.
	Third great mammal fauna, mammoth, cave bear, giant elk, bos primigenius, aurochs, reindeer, horse, man.	Glacial period, succeeded by our present flora.

By the help of the table given above it is easier to follow the course of development followed by the organic life of the world. First of all we see that the development of animal and vegetable life does not progress contemporaneously with equal strides, but that here and there a greater advance is met with, either in the flora or the fauna.

The development of vegetable life is divided by some writers into four great epochs: the four kingdoms of seaweed, cryptogamia, gymnospermia, (coniferæ and pines), angiospermia (monocotyledons and dicotyledons).

The first epoch, the kingdom of the sea-weeds, lasts from the first development of plants in the primeval sea down to the strata of II. Formation (Devonian). All the weeds found among the fossils of the Silurian and lower Devonian strata belong to the marine algæ, and, so far as they have been classified, belong to extinct families.

The second period, or kingdom of the cryptogamia, embraces the middle and upper strata of the Devonian, all the carboniferous, and the lower strata of the Dias formation. The types which prevail throughout this long period belong principally to the cryptogamia, with a few gymnospermia as representatives of flowering plants. The cryptogamia are represented in our present flora, but they have undergone considerable modifications. The reeds and mosses which grew to the height of trees in the carboniferous flora have now degenerated into herb-like growths; and if the ferns have been more fortunate, since we still find specimens of true ferns, they yet exhibit such marks of difference, that it is impossible to class the living and fossil forms under one group. The other kinds of cryptogamous plants, sigillaria and wedge-shaped leaf plants, disappear suddenly at the end of this period, and have left no descendants which we can trace back to them either directly or as forming a kind of transition between the past and the present. The gymnospermia of that period belong to the coniferæ and pine tribe. The former have only a distant likeness with the living coniferæ, and the pines shew characteristics approaching our araucaria. Although the tree cryptogamia are very rich in species, and comprise a few gymnospermia among their number, yet the primeval flora strikes us by its extreme monotony, not only in single districts, but as it is found dispersed over the whole world. From the poles to the equator the fossils shew the same type, and belong not only to the same class, but even to the same order. From this we gather that one and the same climate prevailed all over the earth, and that the continents above water were not separated into climatic zones, for cryptogamia and gymnosperms existed in every part of the world.

The third epoch, the kingdom of gymnospermia, and the first appearance of monocotyledonous plants, extends from the transition period of the Lower Red Sandstone to the Triassic and Jurassic formations. In the red and the variegated sandstone we still find pines and tree ferns prevalent. The cycadaceæ now begin to play an important part at the very moment when the carboniferous flora loses its distinctive types. These cycads are found in abundance in the Keuper and Lias strata, and give to the flora of the rocks a marked character, which is heightened by the appearance of a number of cryptogamous plants entirely distinct in form from those of the older Trias formation. A great change is also noticeable in the calamites and ferns of the Keuper beds; the former assume a gigantic height, and resemble the modern ones in other particulars, while the tree ferns of the variegated sandstone have sunk down to the rank of herb-like growths, with only a few exceptions. In the Lias beds they receive forms unknown before, types with broad or jagged leaves, and with a network or star-shaped division, are frequently met with. During the Jurassic period, pines and cycads reign supreme over the vegetable world. The canes have dwindled down to the proportions in which they still exist in the tropics: tree ferns become rarer in Europe, the monocotyledons appear with different forms. No sufficient number of fossils has been found to enable us to determine with certainty the first appearance of monocotyledonous plants, but it is beyond all doubt that they are characterized by highly organized forms as far back as the beginning of the Trias age.

The fourth period, the kingdom of the angiospermia, begins with the cretaceous formation, and is not yet ended. The angiosperms, which, together with the cellular cryptogamous plants, low organized forms of cryptogamia, compose this flora, are divided into two great classes—monocotyledons and dicotyledons; the former, which, in the hierarchy of the vegetable world, follow directly after the gymnospermia, ought to reach their highest development before the dicotyledons are sufficiently developed in any geological period to exercise a decisive influence upon its characteristics. We only know a few palms, some grasses, and very few specimens of other families. Can it be that Nature has here deviated from her invariable rule of proceeding from the lower to the higher? or is not this gap caused by the structure and form of the growths in question? the latter reason is the more probable. Almost all the remains of dicotyledonous plants, which have come down to us from the kingdom of the angiosperms, belong to plants having the nature of trees; the same is true of the monocotyledonous plants which are known to us, almost all of them palm trees, the rest of the monocotyledons are herb-like plants, which have probably yielded to the fate of all other herbs, and have passed away without leaving any sufficient trace of their existence.

The geologist Heer writes of the chalk and eocene formations, with the trees. A whole series of new types, he tells us, with new developments of form, appear in the vegetable kingdom. That division of the world of plants which now makes up three-fourths of the fossil flora was altogether wanting in the earlier ages of the world; the shores of our sea of chalk were perhaps still adorned with isolated cycads similar to those of the Jurassic period, but the landscape received its character from firs, pines, and evergreens; among these were seen fan-palms and other tropical trees, and in the shadow of the forest, the rich growth of numberless ferns covered the ground with their delicate leafage. The flora has a decided Indo-Australian character; proteaceæ and cypresses of Australian habitus abound, and perhaps reach the highest point of their development; these firstborn types are joined in the eocene, or "formation of the new dawn," the catkin-bearing tribe, with mulberry and laurels; in certain localities, indeed, they appear to have driven out the plants mentioned before; at the same time we meet with types recalling water-lilies, heaths, and ebony trees, but as yet there are throughout the whole flora no plants of true European habitus.

The flora of the star-flower plants presents a very diverse and complicated character; the flora of Europe exhibits a mixture of Australian, Indian, and American types; among them we find the catkin-bearing tribe, willows, oaks, beeches, laurels, and mulberry, magnolias, vine, myrtles, limes, and a still greater number of maple, buckthorn, terebene trees, etc. The pulse tribe alone is represented by more than one hundred and fifty kinds of more or less strongly marked varieties; we see also heaths, bindweed, and olives.

The period of bell-flower plants begins with a small number of types of the miocene period, after which they multiply rapidly. The Indo-Australian character of the European flora retreats to make way for North American types, until at length the present formation and distribution of vegetable growth is established. The present flora is still in a state of unchecked development; for the typical forms are yet prevalent, and the varieties are proportionately numerous.

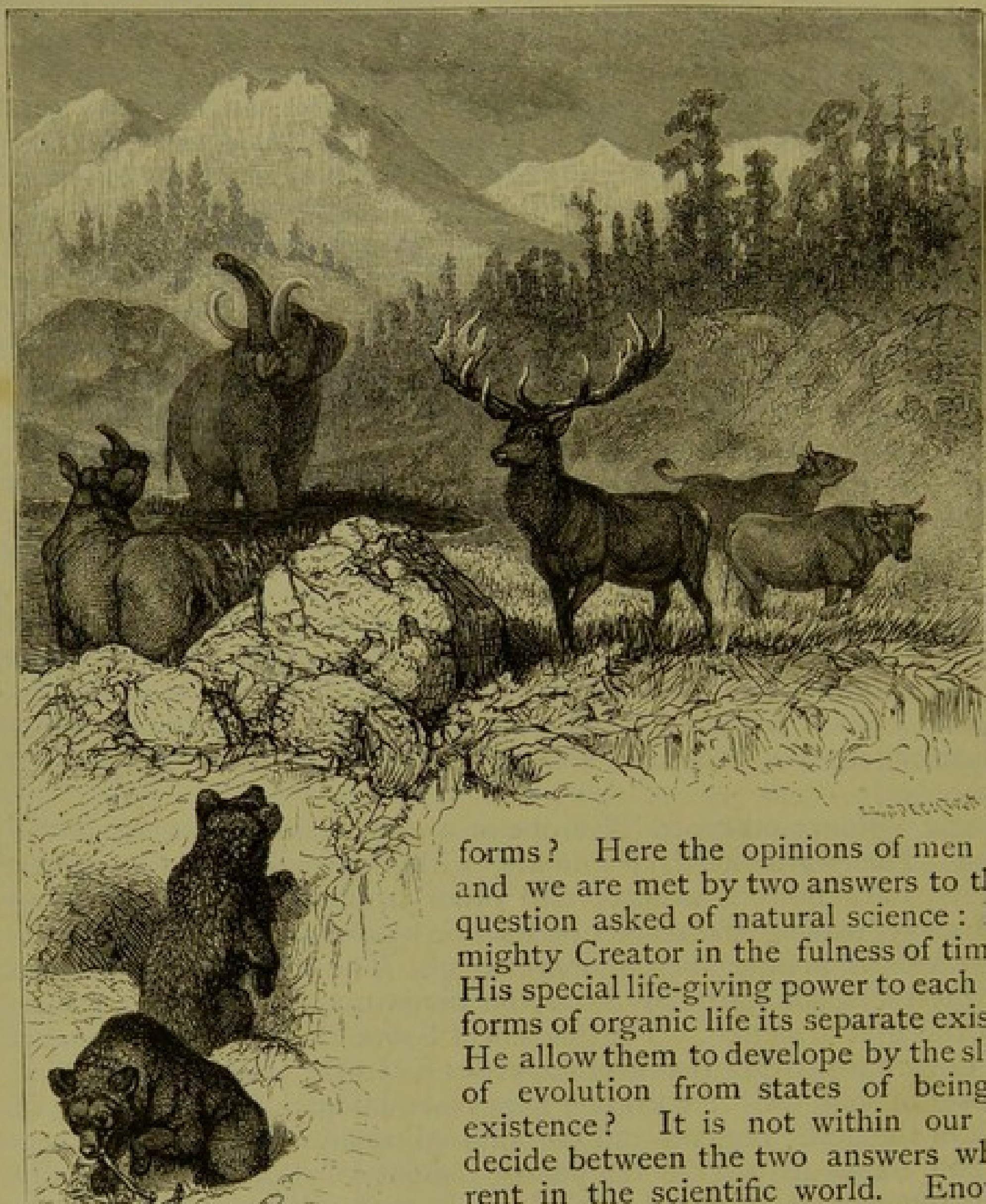
Thus, then, the geology of plants, in spite of its many gaps and deficiencies, presents a grand and at the same time a simple picture of a gradually progressive development, an advance from the simple to the complex, from the lower to the higher type.

The same law is observed in the animal kingdom; but it is not necessary to trace at such length the development of the old-world fauna as we have done its flora. From the preceding table it is easy to trace the first appearance of crabs, cephalopods, fishes, reptiles, birds, and mammals, until we reach the crown of organisms, and Man appears, the ruler of the animal and vegetable kingdoms.

A slight sketch of the primeval mammal world, as it existed among the classic scenery of Attica, may take the place of a dry classification of names. The researches of Gaudry at Pikermi bring before us an image of the grey past of the miocene age, when Attica presented a far different aspect from the Attica of to-day. The land was more fruitful, richer in fertile pasture land and majestic forests; beneath its skies sported the two-horned rhinoceros, side by side with giant boars; apes climbed the trees, martens, several of the feline tribe and other carnivora, hunted the prey. The yawning caves found in the marble of the Pentelicon served the hyenas for their dens and places of refuge; countless herds of quagga, zebras, and hipparions, all representatives of the equine race, galloped across the plains; rivalling them in grace and speed appear the ancestral types of the graceful antelope; there too, was seen the spear-horned palæoreas, the lyre-horned antidorkas, the sabre-horned palæoryx, the ram-horned tragocerus, the narrow-headed palæstragus. The helladotherium was an animal recalling our giraffe; an imposing specimen of the odentata moves side by side with the gigantic mass of the monster dinotherium, a terrible beast, with hanging tusks and an elephant's, trunk, worthy companion to the monster mastodons; down from the mountain slopes came the yell of the dreaded sabre-toothed machairodus cats. Mingling with the cries of these and many other mammals, was heard the song of birds; only the voice of man was wanting; for the primeval world of Attica was an animal world, such as meets us now in its wild majesty and savage strength in the woods and deserts of central Africa. Many, but not all, of the types have changed since then; even at the present day the hoofs of zebras and quaggas trample down the deserts of Kalahari and the grassy thickets of the Congo; the kindred of the miocene antelopes, koodoos, elands, wild goats, etc., still inhabit the grassy plains of the African Karroos; hyenas still sleep away the day in the rocky clefts of Senaar and Abyssinia; civet cats glide through the forests; martens watch the poultry of the negroes; the giraffe steals through the acacia groves; the rhinoceros dwells in the lakes, and the gigantic wild boar breaks through the millet fields. The chimpanzee traverses the fruitful enclosures of Loango and Niam-niam, while the fig-tree woods of the west are the home of the powerful and savage gorilla. Baboons climb the heights. Many things in the old primeval world have, it is true, changed at the present day; the Attic sabre-toothed machairodus has made way for the lion and the leopard of Africa; instead of the mastodon, the long-eared elephant breaks down the thicket; the wild ass fills the place of the hipparion; the dinotherium and other monsters have disappeared without a trace.

Let us cast a glance on central Europe at another period; we are in the Diluvian age. The warm tertiary climate, with its wealth of fan palms, feathery palms, lotos flowers, acacias, and other tropical growths, has long since passed away, leaving the secrets of its life hidden in the silence of the rocks, to be revealed in ages then undreamed of. The cold of the northern hemisphere increases, and little by little the lands are bound down by the icy bands of the glacial period. The glaciers of Switzerland and Scandinavia advance far downward within the level countries. North America lies buried beneath masses of solid ice. An Alpine flora resembling that now existing in the far north of the arctic regions, and the kindred mountain flora of Switzerland, was then found in all the temperate regions of Europe. Specially interesting is the animal world of this glacial period. We find among its fauna marmots, snow-hares, the well-known migrating rodent the lemming, cave-bears, gluttons, wolves, martens, weasels, otters, chamois, the giant stag (*Megaceros hibernicus*), boars, reindeer, aurochs (*Bos primigenus*), bos priscus, musk-oxen, mammoths, and the rhinoceros with bony division of the nostrils (*Rhinocerus tichorinus*). The two last-mentioned animals were at that time covered with long hair, and so fitted to brave the severe climate. Many of these species are now confined to the heights of Switzerland, Scandinavia, Illyria, and the Pyrenees. The musk-ox is found only in the north. The bos priscus is met with only in Lithuania and the Caucasus; while the mammoth, rhinoceros (*tichorinus*), giant stag, and aurochs, have died out.

And now we find ourselves confronted with the most important question asked by the natural science of to-day. We saw that in the remotest past the surface of our planet was bare, and destitute of every form of organic life. We saw how by degrees it became clothed with the green carpet of vegetable growth, and animated by the presence of living creatures. We saw also that each of the two great types of organisms, plants and animals, began with simple forms, and did not attain to their present stage of development until a period of time of unknown duration had passed away. Whence arises this advance from the simple to the complex, from the lower to the higher forms? Here the opinions of men are divided, and we are met by two answers to the dominant question asked of natural science: Did our Almighty Creator in the fulness of time impart by His special life-giving power to each of the higher forms of organic life its separate existence, or did He allow them to develope by the slow processes of evolution from states of being already in existence? It is not within our province to decide between the two answers which are current in the scientific world. Enough to have indicated the conflicting solutions of the problem; but the means and ways by which the development of the higher organisms is supposed to be attained lead us to consider chiefly the laws governing the necessary conditions of life, and the transmitted qualities of heredity.



ANIMALS OF THE GLACIAL PERIOD IN NORTHERN AND CENTRAL EUROPE.

Cave bear (*Ursus spelaeus*). Rhinoceros (*Rhinocerus tichorinus*). Mammoth (*Elephas primigenus*). Giant stag (*Megaceros hibernicus*). Aurochs (*Bos primigenus*).

Let us then first consider the necessary conditions of the life of plants.

Heat.—Near the poles plants sleep through the winter, and near the equator they sleep through the dry, burning months of summer; in the one place the limit of their development is fixed by heat, and in the other by cold. No plant can sustain for any length of time a temperature below freezing point; the activity of its organs begins when the temperature reaches the vital juices at a certain degree above freezing point. As the heat rises, an acceleration and increased energy of living activity is exerted, and increases to a maximum at a certain degree of heat. Beyond this degree the activity and energy of the vital functions decrease, until at length they are brought to a standstill. The maximum degree of heat, beyond which no plant life flourishes for a length of time is 122° Fahr. Within this wide range the collective life of the vegetable world puts forth its various forces; but the amount of heat required by separate plants is of course infinitely various. We recognize this heat, perhaps, by our wild plants. Scarcely has the frozen snow of winter yielded to the mild radiance of the spring sunshine than myriad tiny plants put forth their blossoms or green leaves, and the eye is gladdened by the willow catkins, the hazel buds, and many a familiar woodland flower; while many a forest tree has clothed itself in its vesture of green before its comrades have cast off their last dry leaf. Some plants require even less warmth than these. As soon as the stunted arctic willows, which measure their length by inches, are touched by the first rays of the sun, the catkins begin to bloom, although any renewal of the sap from the ground is not to be looked for for many weeks. The sun can only thaw the sap frozen in the buds and knots at the extremities of the plants, and they immediately obey its impulse, and put forth their leaf, while the greater part of the organism, the root, lies frozen hard beneath the ground, and perhaps never reaches its full development of sap, and its corresponding growth, except in unusually favourable summers. Equally wonderful also is the life of many plants growing on the outskirts of the Alpine snowfields. The melted water filtering through the ground suffices to keep the life in the plants buried beneath the ice and snow. Now this life process developes heat, and the heat so generated is sufficient to melt the frozen covering. The growing plant manages in this way to make some space in which it may shoot upward, and at last the little stem pierces the bed of snow which lies above it often to the height of two or three inches. It is a strange sight to see the outskirts of the snowfields perforated and intersected with flowering plants, chiefly Alpine bells (*Soldanella*). And the few winter plants of our own land, hellebore and daisy, for instance, freeze in every stage of their development, and resume their growth as soon as a thaw sets in. While so many plants therefore seem to bear a charmed life from cold, others are just as able to defy high temperatures, and manifold are the ways in which they are protected from the cold and drought. Some by an enclosure of thorns, some by a downy coating of hairs, others again by ethereal oily essences or an impenetrable skin. Very often the organs which suffer most from heat, such as the leaves, are wholly wanting. This is seldom or never the case with the whole vegetation of any district. Even in the hottest parts of Nubia certain shrubs retain their scanty adornment of foliage when all around them is parched and leafless; in other places the plants which are able to retain the sap, thanks to the power of their organic life, are thus enabled to continue their growth through long seasons of drought. The cactus and euphorbia are instances of this power of endurance. Apart from such exceptionally protected plants, the power of the sun's heat is widely felt, and its traces easily seen. Along the banks of the Nile, for instance, it is in vain to search for a tree which is not partially dried up; the bark of the trunk, or a bough, or perhaps a withered parasite, disfigures and mars the tree. It follows, therefore, that plants require a certain definite amount of heat; and it is the same with the light which the sun sends out at the same time. For the process of assimilation, that mysterious activity by which the inorganic nourishment (especially the carbonic acid said so often and so inaccurately to be "breathed in" by the plant) is united to organic substances, can continue only by the co-operation of light. It is true that in many respects the growth of plants appears to be wholly independent of light; the seeds begin to germinate, the bulbs and tubers to form, the buds to develope through the thick opaque bark of the boughs, whole branches grow, even blossoms and fruits which enclose the seed are able to come forth without the aid of light. But the sense in which this is true is a very restricted one; for although the seed sends forth the young shoot in utter darkness, yet the growth is only carried on at the expense of the material stored up within the seed, and that material was created under the influence of light. The law is analogous to that which we recognise in other instances, where the power of light is converted into other forces concealed within each grain of starch, each drop of oil, or particle of sugar which builds up the growing plant, so that in the last resort we come back to the fact that it is light which gives to plants, and through them to animals and men, that nourishment which is an essential condition of their existence. Even the subterranean plants, such as truffles, are not excepted, although of course they are never reached by a ray of light; for their food consists of substances which have been formed under the influence of light. Moreover the strength of the light is of essential influence, as is shewn by the defective growth of indoor plants, which so often fail for lack of power; and the same is true of the so-called *shadow plants*, given to certain kinds which shrink from a very sunny position. It is deficiency of light which prevents the growth of plants overshadowed by dense fir plantations or pine woods. Although science has not yet discovered any certain results as to the amount of light required by plants, it is beyond all doubt that there is a minimum of light, as there is a minimum of heat, and that this minimum must exist before any process dependent on light for its continuance can be carried on, and that the energy of the process decreases with the intensity of the light. It is also probable that the vital activities reach their maximum at a certain degree of light, and that when this degree is exceeded they diminish. It would be interesting to know whether this light maximum is ever exceeded, or even reached, in ordinary sunlight; we know that it is so for many plants, such, for instance, as the shadow plants we have mentioned above, but it is by no means certain that it is so for all. In a physiological point of view, very little is known of the effect of long-continued light upon the vegetable world, or the influence of the long arctic day upon the life processes of northern plants. Perhaps the unusual size of the blossoms and their vivid colouring may be at least partially ascribed to the arctic day of several months in length. However that may be, the fields of Nova Zembla, with their wealth of purple saxifrage, their blue forget-me-nots, golden buttercups, white mouse-ears, pale pink primulas, and other flowers, look like a garden planted by the hand of man in the icy region, bounded by glaciers, and arranged so that the eye, dazzled by the wealth of colour, scarcely misses the green of the scanty foliage.

The duration of the time of vegetation is but slightly known with respect to its influence upon the life of plants, for it has to be considered in the case of a relatively small number of plants. Wherever, for instance, a late summer and autumn fail to bring more warm days, the culture of the vine is impossible, because the sunshine is essential to the ripening of its fruit. From an examination of the "tree boundary line," that is to say, the line drawn to mark the limit at which the growth of trees ceases near the pole, we are led to conclude that trees can only thrive when they are able to command a period of about three months for the completion of their growth. The larch seems the only tree which can do with a shorter time, as in certain parts of Siberia (lat. 72° N.) it wears its crown of foliage for ten weeks only.

All the necessary conditions of plant life which we have mentioned as yet may be summed up in the one word climate. But when we attempt to specify the separate factors which compose this word, we find that the idea of climate is exceedingly complicated. It comprises the distance of a given place from the equator, its height above the level of the sea, the maximum and minimum average temperatures throughout the year, the annual and daily variations of temperature, and their effect upon the duration of vegetable growth, the moisture of the atmosphere, and the distribution of moisture throughout the various seasons, and, finally, the amount of wind and light as it is imparted to vegetation by the greater or less clouding over of the sky, and the varying length of day and night.

A second necessity of plant life is food or nutriment. From the atmosphere the plant absorbs its carbonic acid, and transmutes its carbon into the characteristic element of vegetable organic substance; from the earth it absorbs water and mineral substances. The latter are absorbed by aquatic plants from the water in which they are held in solution. Water itself is also a source of nutriment, and if it were not so cheap and so readily attainable, if we had to pay for it as we have to pay for wine, we should soon be forced to acknowledge that it is of all the necessaries of life the most indispensable.

In the present state of our knowledge of this subject, the least scientific countryman knows that different kinds of plants satisfy their need of food in very different degrees from the same soil. He knows, for instance, that all kinds of pulse prefer lime, that turnips and potatoes thrive upon potash, wheat upon phosphate and silica, and he regulates his agricultural operations and the manuring of his fields according to his knowledge. And in the same manner we find that certain plants are restricted by nature to their own kind of soil, where they find an abundance of the special food which they require for their growth and well-being; and that just as a beast of prey strives to protect his booty from unwelcome intruders, so does the plant growing in its own proper soil expel all other plants from its domain. In the Bernina Valley (Upper Engadin) the achillea (milfoil, or common yarrow) is found growing near the achillea atrata, and a third variety, known as musk milfoil. The latter seeks a slaty soil, and the achillea atrata prefers limestone. Wherever the slate is replaced by lime, the musk milfoil ceases, and its rival takes its place. In such a case each variety keeps to its own ground, and it is always in places where the two kinds of soil are found that the two varieties of milfoil are seen together. It by no means follows that the achillea atrata cannot grow upon slaty soil, or the musk milfoil on limestone; for wherever only one kind of milfoil is found, it grows indifferently on either kind of soil, the achillea atrata taking kindly to the slaty ground, and the musk milfoil flourishing, though not so freely, it must be confessed, on the limestone. What, then, is the reason of this duel *à outrance* between these two allied species? It can only be explained by supposing that whenever one of the kinds is found growing upon its own favourite soil, it is strong enough to destroy and thrust out its rival in the struggle for existence. This preference shewn by plants for different kinds of soil furnishes us with the key to many a puzzle in natural history. The *Pinus silvestris* (Scotch fir), for instance, is found farther north than the pine (*Picea excelsis*), while in Switzerland the pine grows higher than the fir.

It is a common error to suppose that the cold prevents the fir from growing on a higher level; very few trees have such power of endurance and adaptation to the changes of climate. It grows in the moist air of Finmark, where the summers are cool, and in the hot moist summer and cold dry winter of Siberia. The difference of soil is the only reason—a reason which may be proved to demonstration where the geological formations above mentioned are found together within the limits occupied by the plants. Nowhere perhaps is the connection of geological formation and vegetable growth seen more clearly than in what once made up the triassic landscape of Germany.

At the present day, variegated sandstone rock covers the old Hercynian forest of Tacitus. Whoever has seen the true forest as it exists to-day untouched by modern culture, whether in the Black Forest, or the Vosges, in Odenwald, Spessart, or Thuringia, can never forget the impressive nature of the scene. A sombre stillness reigns around. Patches of soil and bare rock are seldom seen; for the earth is covered with a thick carpet of moss, broken through by ferns, and where the wood clears a little, by tall red foxgloves and yellow broom. Where the moss ceases, the earth is covered by different coloured lichens, white, grey, and black, like those seen in the far north. Armies of white fungi spring up in ghost-like array during the silence of the moist autumn nights. Here and there upon the steep ascents of the forest is seen a chaos of jagged rocks, which have been precipitated into the valley by the erosive force of wind and weather, piled up in fantastic shapes, an inaccessible "devil's fortress." The knights and barons of the middle ages thoroughly understood how to choose the sites of their robber castles; Trifels, Altdahn, and many another ruin in the Vosges and the Black Forest, bear witness to their wisdom. So long as the tall forest trees stand on the sandstone heights, the traveller feels soothed by the solemn hush of nature, stirred only by the touch of the wind through the crests overhead. But the forest has another aspect. The wood becomes lighter, the trees grow meagre and stunted, parasitic growths hang downward from the branches; the fir cones lose colour; the scenery of the marsh and moorland begins; firs and pines disappear; a stunted undergrowth bends toward the earth in the direction of the wind; a dead, desolate scenery, with lonely tarns gleaming here and there, brown and weird; no ripple breaking the dark surface of the water. The traveller longs to leave such forest heights as these for the woodland scenery of tree and waterfall, where far below the fertile valleys wind like gay coloured ribbons through the sombre woods.

But when we leave the sandstone formation, and descend to the shell limestone, we come from the forest to the field, from true forest landscape and backwood scenery to farms and homesteads, from lonely isolated hamlets to towns and villages. For miles together the cornfields wave over the undulating plains, while pasture land and clusters of trees crown the heights. The rich valleys would soon become monotonous and dreary, if the Neckar, the Sauber, and the Main had not lent their aid, and carved out deep beds in the shell limestone rock, and formed a lovely contrast to the heights. The limestone surface extends for many miles, until it is buried beneath the sand and marl of the Keuper formation. Bright coloured marls, red, yellow, grey, and green, form the fertile soil of the vineyards of Lorraine and Suabia, and the hop-fields of central Franconia, lovely, peaceful spots, where the busy toil of man is as manifold as the varying colour of the ground on which he lives.

Until very recently the distribution of plants was considered to be wholly dependent upon climate and the formation of the soil; but at the present day the conditions of palæontology, the friends and foes of plants, and the possibility of reproduction, must be taken into consideration.

For instance, we have to attempt to trace back the genealogy of our modern plants, and discover their ancestral prototypes in remote geological periods, for climatic changes continued through successive ages must have taken effect upon the development of the later types; and if we find that not every plant originates in every place which presents the necessary requisite for its well-being, that there exist, so to speak, certain centres of vegetation, we must explain the existence of such centres by the influence of geological and palæontological circumstances, as we shall have to explain more closely in our remarks upon the fauna of the Sunda Isles.

The friends and foes of plants, amongst whom man holds a prominent place, must also be considered. We will give an example in which an insect appears as the deadly enemy of vegetable life.

It was on the 27th of July, 1853, in the neighbourhood of Schwalger, near the Rothebuder forest, that a swarm of the butterfly *Liparis monacha* suddenly appeared, driven by the south wind. It came in vast masses like flying clouds, or, according to the testimony of an eye-witness, like a blinding snow-storm. Between the 8th of August and the 8th of May in the following year, 150 million eggs, representing a weight of three hundred pounds, were collected, besides more than a million and a half female butterflies captured during the flying season. But these energetic measures were of no avail, although they were supplemented by the vigorous endeavours of woodpeckers, finches, ichneumon-flies, beetles, and other creatures. In the following year the crests of the young firs and pines were bent down under the load of the chrysalis hanging upon them. Every branch was weighed down; not one green leaf or blade of grass was left as far as the eye could reach. Out of an extent of fir plantation covering 250,000 acres, an area as large as three-quarters of the royal forests of Saxony, exclusive of all the private forest lands, where the damage was equally great, not one tree resisted the inroad of the enemy. At the present moment, thousands of acres are still in a state of indescribable desolation. The timber of the trees eaten by caterpillars soon deteriorates in value, and where could a purchaser be found for the quantity so suddenly thrown into the market? Between the forest trees still left standing, though much damaged by the fallen pines and firs, and among the numerous stumps half charred by the fires of the wood cutters or the clearing of the burnt scrub, lie old tree trunks mouldering away, broken and rent asunder by storm, overgrown with raspberry brambles, nettles, and ferns, and covered from crest to root with parasitic lichens. Above this chaos tower the naked forms of isolated yoke elms or aspens, some still rooted in the ground, some broken off short, high in the air. The gaunt white branches gleam forth weird and skeleton-like from the dark luxuriant green of the impenetrable mass of raspberry bushes. The spots which have been left untouched present a terrible appearance. Where the firs are found in great numbers among the dominant growth of pines, and wherever the wind has been kept out by the close ranks of the trees, the withered pines are still erect; as far as the eye can reach, nothing is seen but the mouldering corpses of trees wrapped in their bleaching shroud of lichen; and on the ground a tangled growth of briar and bramble. A death-like stillness prevails; the wind no longer sighs between the leafy crests; no bird's voice echoes through the dry wood: even the woodpecker, which in the untainted parts of the forest is eagerly tapping at the red shafts of the pines, in search of the bark scarabæ, has long ago forsaken the desolate spot;

for not a beetle or caterpillar is left to reward his search. At the same time the plantations of the Prussian provinces were attacked by the same enemy, and the trees destroyed by the pest yielded the enormous amount of 12,000,000 cubic yards of timber. Surely such a catastrophe as this may be compared with the Egyptian plague of locusts.

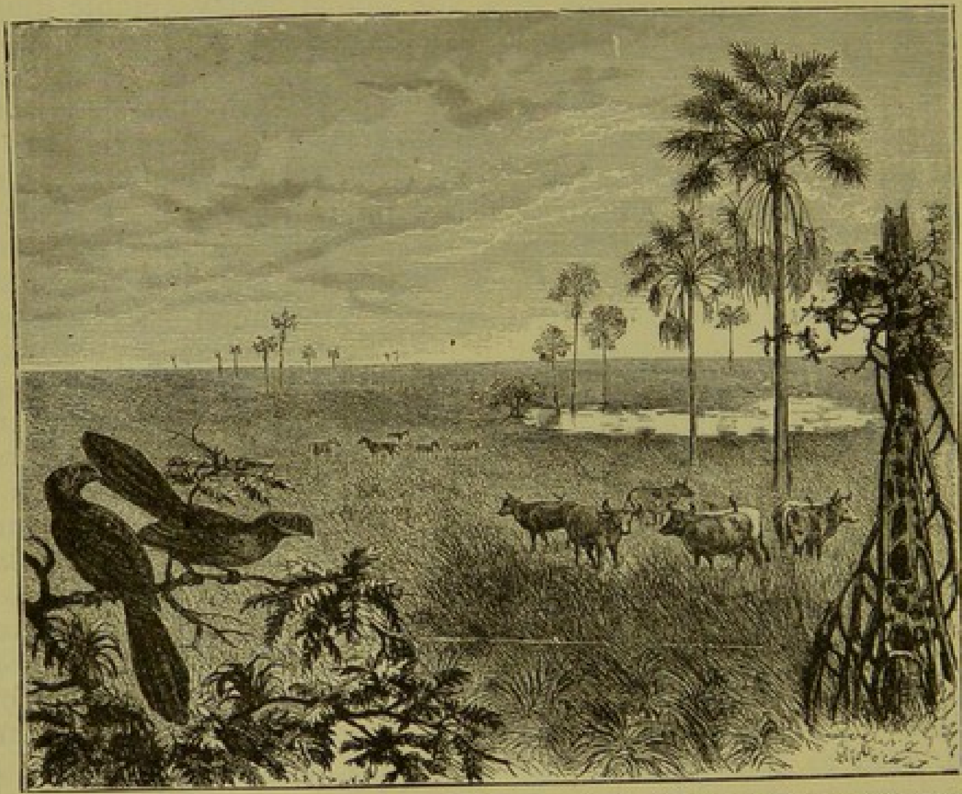
Lastly, we must consider the plant with respect to its power of reproduction. Conrad Sprengel was the first who, in the year 1793, threw a new light upon this subject in his book "On the Newly Discovered Mystery of Nature in the Growth and Fertilization of Plants." In this book he asserted for the first time that it is of comparatively little use for flowers to fertilize themselves; in other words, that a plant will not thrive so well when the pollen formed within it is used to fertilize the embryo of the same flower.

LIPARIS MONACHA IN VARIOUS STAGES OF DEVELOPMENT, EGGS, YOUNG AND ADULT CHRYSALIS, CATERPILLARS. The male flying, the female resting. Natural size.

But Sprengel disfigured this truth by the addition of so many strange fancies that his new discovery received but little attention from scientific men, until Darwin, if we may so speak, discovered it afresh in his book "On the Arrangement for the Fertilization of British and Foreign Orchids by Insects." Since the publication of this work it has been proved by numberless observations, not only that there are in nature many plants which are fertilized by pollen brought to them from other flowers, but that many plants cannot be fertilized at all, except by help from outside; and this help is carried to them by the agency of the wind and small living creatures, especially insects. The latter creatures have important and varied tasks entrusted to their care; for there are many flowers, of which the blossom is so shaped that the wind cannot open it to remove the pollen and carry it to other flowers; so that a numerous class of plants are fertilized by the help of special insects appointed to wait upon them for the purpose. For instance, figs are fertilized by a certain kind of gall-insect, other blossoms by blue-bottles, *Epipactis labifolia* by wasps, the different kinds of roses and peonies by beetles of the family of the rose-scarabee, the *Rhodea Japonica*, belonging to the order of *Aspidistreæ*, by tiny snails, and a very large class of plants by insects of the bee tribe and small birds of the humming-bird family. Native flowers and plants are naturally always provided with their special insects or birds who have charge of their fertilization; but whenever, in the case of any foreign exotic, there are no living creatures at hand to carry the pollen to its blossoms, it remains barren, and is checked in its development. The lobelias cultivated so frequently in our gardens may serve as an instance. The blossoms of the lobelia syphilitica are visited by humble-bees, and in consequence produce seed; while those of the lobelia fulgens, notwithstanding their size, and the large quantity of honey they contain, are visited by no insects, and consequently produce no seed; although they seed freely after artificial fertilization. But even our native plants suffer sometimes from this intimate connection between the animal and vegetable kingdoms. In the year 1878, for example, the humble-bee, which fertilizes the so-called broadbeans, was in many parts of the district of the Lower Rhine comparatively rare, in consequence of which the plant in that neighbourhood yielded only a scanty crop of its useful seed. The connection between plants and animals is so close, that, generally speaking, the size of the blossoms corresponds with that of the animals which fertilize them. If we pass in hasty review some of the largest European blossoms, such as the peonies and convolvuli, we find, according to Delpino, that the former are fertilized by large rose-scarabees, and the latter by the hawkmoth. As we advance farther from the tropics towards the regions of the north, we can trace the gradual disappearance of certain plants, owing to the gradual diminution of the birds and insects appointed for their fertilization. The whole tribe of peonies and roses must necessarily cease when they find no more rose-scarabees; the majority of the pink tribe, especially those classes which blossom at night, cannot exist where there are no night butterflies; and only those flowers can penetrate to the Arctic regions which are dependent for their fertilization either upon the bee class, or upon flies, or upon the wind. In our own country, something analogous takes place during the revolution of the seasons from spring to autumn, to what occurs in the transition from the temperate zones to the pole. In the early days of spring, before the insects appear, the plants fertilized by the agency of the wind come into blossom, such as pines, catkin-bearers, grasses, and sedges. Then, as the summer draws on, it enables those flowers which depend on insects of the bee tribe, such as heaths, delphinium, eschscholtzia, and lobelia ramosa, to unfold their petals. In autumn this class of insects gradually disappears, and the above-named flowers are replaced by others more capable of resisting the cold, and for which hardier insects are in attendance. Thus at every change of season there is a change of flora, and new plants are found waiting for their new attendants.

This connection existing between plants and animals leads us by a natural train of thought to the necessary conditions of animal life, and here, as we should expect, plants fill a most important part. Indeed, it may be said that an animal kingdom organized like the fauna of to-day is utterly impossible without the existence of a vegetable kingdom; for a great number of animals are herbivorous; and even the carnivora would soon be deprived of their food, if it were not for the presence of grass-eating animals, for the simple reason that it is only possible up to a certain point for the animal kingdom to transmute inorganic into organic substances; that is to say, to compel carbon to unite with other elements. Broadly speaking, animals have the same conditions of existence as plants: they need a suitable climate, food, and protection from dangerous enemies. This subject is full of interest, and opens out a wide and attractive field for the observer. Perhaps it has been most fully treated by the German naturalist, Semper.

And first as to food, considered as one of the necessary conditions of animal life. Leaving it for more technical books to give a long list of herbivorous animals, with the special food preferred for each one, a single instance will be sufficient to shew how strictly the distribution of animals is dependent upon the distribution of plants. Denmark is famed for its magnificent beech woods. Oaks and pines are rarely found there, and we know that in the times of the Romans it was already the same. In the turf moors the remains



LLANOS OF VENEZUELA, WITH COBIJA PALMS (*Copernicia tertorum*). In the foreground to the right, Ficus dendroica clinging to a Palm which it has destroyed. To the left the insectivorous Crotophaga ani. Similar Birds are perched on the Cattle.

of oak woods are found in the upper strata, and on digging deeper pines are met with. Now there have been discovered the most wonderful remains of a prehistoric age, from which we learn much concerning the food of the primeval inhabitants of the north. These so-called *kitchen refuse* (*Kjoekken moeddings*) contain heaps of oyster shells and bones of various animals, besides numerous tools and implements which teach us their silent lesson of the past history of Denmark's natural productions and vanished races. They teach us first that in Denmark, as in Norway, the land was covered by vast forests of pine trees, and that in Denmark the woodcock, a bird which is now found only in rare and isolated cases, was met with in large numbers, but has almost vanished, together with the pine woods. But this cannot surprise us, as we know that this bird feeds almost exclusively on the sprouts and seeds of the pine and kindred plants. Animals are also dependent upon each other, as well as upon plants. In San Martin, the district east of the Andes, belonging to Columbia, we find the home of the wild cattle (*Ganado vacuna*); there are only a few enclosures, surrounded by a fence of bamboo canes, to receive them at certain times. It is a glorious sight to see the fine creatures bedded in the deep grass, and sheltered from the burning sun by the wide leaves of the palm (*Mauritia flexuoso*). Perched upon their backs and heads, as they lie quietly enjoying their rest, the insect-eating falcons busily destroy the tormenting insects in their shaggy hides. These terrible little pests settle by preference in the ears of the cattle, and the wounds they make would often become fatal, were it not for the friendly help of the insect-eaters. The cattle recognise the birds as their friends and protectors, and allow them every familiarity, living with them on as friendly terms as in the llanos with the ani (a bird belonging to the cuckoo tribe), and as the buffaloes and elephants of east Soudan with their respective attendants of the insectivorous bird class.

The animal is far better able to defend himself against the hostile influences of climate than the plant. The latter is in many respects absolutely helpless. It is rooted to one unchangeable spot, while the animal has caves, dens, and coverts, in which to seek for shelter against storm and cold. To many animals the change of the seasons brings its own protection: the fur grows thicker, the hair longer, the light summer clothing is exchanged for the warm covering of winter. In other animals the vital activities are depressed during the unfavourable season of the year; so with the alligators in the rivers, and the Venezuelan llanos in the hot, rainless months, and with the bats of our northern climate during the cold winter. Other animals, especially some insects, which, like the butterfly, pass through a series of transformations, exist in the winter only as eggs or chrysalis, and wait for the summer months to appear in their fully developed state. It is not necessary to adduce examples of every kind, it will suffice to mention the winter sleep of bats and the migration of birds of passage. Scarcely have the autumn nights become cooler and the insects rarer, than the bats, those most innocent flutterers, whose reputation is so unjustly blackened by the ignorant, disappear from our streets and squares and wall-tops, or from whatever place they have chosen for their summer haunts. They retreat often in large masses, and generally to the same spots which have served them for hiding places during the summer months—chimneys, cellars, hollow tree trunks, broken walls—each genus having its own special place of preference. Bats from a great distance round often assemble in their favourite winter quarters, and the most northerly kind, the *Vespertilio nilsonii*, even migrate southward for the winter. The position in which they pass their winter sleep is different in all the different branches of the tribe; the majority hook themselves to the wall or other object by their hind legs, fold their wings to their side, and, with their head downward, await the time of their awaking. And then, as the temperature decreases, the vital powers diminish with it; the respiration is slower, and the heat of the blood often sinks below 34 F. It is a curious and striking circumstance that such a greedy animal as the bat, which requires so many insects for its food during its waking hours, should be able to pass more than a third of its existence without any nourishment whatever; but the effect of its long fast is clearly seen. At the beginning of its winter sleep it is very fat, the amount of fat often indeed outweighing the rest of the body; this fat decreases daily, and when the bat awakes in spring to its new life, it is consumed down to the last remnant, having been used up to support life through the long winter sleep.

When the first autumn moulting is over, and the cold season, in which nourishment is more difficult to obtain, draws nearer, the impulse which drives forth the long chains of birds of passage rises and makes itself felt; and they leave their homes to seek for warmer lands, where a table is spread for them. Those which have strong and swift wings set out by day; the weaker ones choose the night for their migration. Storks fly high, snipes low, ducks in a straight line, geese in a slanting line, cranes in curves, finches and swallows in a more or less dense cloud. They set out upon their way, to return in the warmer season. We cannot tell what impulse urges them to leave their home, for they start when food is plentiful, and not one of these travellers has ever been able to find out the necessity of the journey. The winter quarters of the migratory birds are at greater or less distances from their summer home; some of them, as, for instance, field larks and many finches, winter in the south of Europe, where they are captured and consumed by hundreds; others, such as swallows, penetrate far within the tropic zone. And yet each bird returns in early spring to the self-same nest it built in the preceding year, or to the neighbourhood where it escaped from the egg. We cannot tell how this is possible, but the fact is beyond all doubt, and meanwhile we can only suspect that the magnetic pole, and its corresponding magnetic meridians, direct the flight of the birds of passage. Birds are not the only creatures with migratory intincts. We shall have to speak later on of the migrations of herrings, lemmings, and other creatures.

In considering the way in which animals are dependent upon climate, we must not hastily conclude that animals which we now find living in very hot or very cold climates are unable to exist in any other. The tiger, for instance, is generally regarded as a purely tropical animal, and yet it constantly frequents the cold plains of Manchuria and the Amoor, countries where the winter climate is almost arctic. Few animals seem to be such genuine inhabitants of the tropics as the elephant and the rhinoceros, and yet it is proved that in past geological periods they spread over all the northern countries, even to the frigid zones, and we know that the climate was as cold then as it is now, because their bodies have been found preserved in ice.

We need not repeat in somewhat different fashion what we said of the gradual development of plants, and shew how animals are equally dependent upon the place of their birth, and how their restriction to certain places can only be explained by palæontological circumstances. We will only add some of the means of protection by which certain animals are enabled to conceal or defend themselves, and first of all, of the adaptation of the animals to their surroundings. Hartmann, in his studies of the deserts of east Africa, tells us how the animal world of the desert assumes the colour and surface formation of the masses of rock and sand which make up those dreary solitudes. The apes found there, the hyrax, mice, meriones, jerboa, foxes, gazelles, jackals, birds, reptiles, and insects, all wear a more or less pale, dull yellow, or greyish brown dress, which scarcely allows them to be distinguished from the desert sand of the same colour. Nimble in their movements, they are able to avail themselves of the slightest inequalities of the ground to shield themselves from pursuit. Advancing in wary jumps and springs, gliding, crawling, and grovelling, with many a pause and rest, crouching down close to the dusky-coloured earth, listening and looking round with unceasing watchfulness, the creatures of the desert know well how to elude the pursuit of their foes. Thus it is a matter of great difficulty to capture a lizard, a centipede, or a grasshopper. Just as the nipple shell (*Patella pellucida*)

YOSEMITE VALLEY.

assumes the colours of the seaweed on which it lives in the waters of the North Sea, appearing like a faint coloured piece of horn on dark stems of the sea grass, and putting on a purple hue with long lines of pale blue when it rests on the transparent leaves, so does the insect (*Eremophila kamsin*), a creature of the desert round the old cities of Memphis and Hermonthis, assume the colours of its birthplace, and appear clothed in pale grey upon the white limestone, in yellow upon the yellow desert sand, and in a darker shade upon the dark-brown rock. Wallace has written much upon this power of protective mimicry imparted to living creatures. He tells us that the butterfly (*Kallima paralecta*), a member of the same family as our own insect (*Apatura iris*), but a native of Sumatra, is a strikingly brilliant creature. Its upper side is a rich crimson, with flecks of ashen grey, and right across the front wings a vivid belt of orange, so that it is very striking as it flies. In dry copses and

LEAF BUTTERFLY (*Kallima paralecta*) FLYING AND RESTING.

thickets it is by no means rare, and yet the naturalist found it exceedingly difficult to capture, thanks to its adroit method of escaping into a bush, and hiding between dry and dead leaves, where it was impossible to find it. At last he was successful in discovering the place where it had settled; but in its position of rest it looked so exactly like a dead leaf hanging from a spray, that even when one was looking straight down upon it, it was scarcely possible to be sure whether it was really a living creature. The ends of the back wings touch the stem of the plant on which the butterfly is resting, just like the stalk of a leaf; the head and feelers are drawn in between the wings, so that the outline of the body copies the shape of the leaf, and the illusion is heightened by the ashen brown and dull red colouring, which is exactly that of a dead leaf. And the same is observed in many other creatures. The weasel is leaf-brown in summer, and in winter whitish brown, or even, in northern districts, white all over. The colour of the ptarmigan of the Swiss Alps changes every month during the summer; in the male, the breast, the lower tail-feathers and the tips of the wings, the legs, and the feathers of the pinions are white in every season; the stems of the pinion feathers and tail are black. The spring moulting, which begins in the middle of April, brings here and there blackish feathers; at the beginning of May the head, neck, back, wing feathers, and chest are black, rust coloured, and speckled; the speckled feathers are spread about and sometimes mixed with white, but all of them bleach by degrees, so that towards the end of August or September the back appears of a pale ashen grey, flecked with black; and in the winter, with the exception of the black, thin, light fringed tail feathers, all the feathers of the male bird are dazzlingly white.

Distribution of Plants and Animals.

As the earth does not bring forth in every place all the plants which could live upon its surface, so the several kinds of animals have a definite and probably, for the most part, a very limited territory allotted to them for their reproduction; but animals and plants have ventured to overstep these narrow limits, and win for themselves large tracts of the earth's surface outside the boundaries of their original birthplace.

Chained to its clod of earth, and incapable of altering its locality at will, the plant is apparently helpless; but it has powerful allies, of which the most important are wind, water, and animals. For the present we will not speak of culture and acclimatization, by which men foster and promote the growth of certain foreign plants. Marvellous are the contrivances by which Nature herself provides for the wide distribution of seeds. Sometimes the fruit, sometimes the seeds, are furnished with wings or hairy crowns, by which the wind may carry them far and wide: we have only to remember these contrivances, as shewn in the dandelion, elm, poplar, and maple. Sometimes the plants open with an elastic movement, and scatter their own seed, as in the case of balsams, wood-sorrel, and a kind of cucumber (*Ecballium officinale*). We must not forget to mention the tenacity of life possessed by the seed. In the year 1176, at Linz on the Rhine, some of the *Crepis pulchra*, a flower extremely rare in Germany, and which had certainly not been seen at Linz within the last twenty years, was found in some earth which had been dug out of the church in the preceding year; so that the seed must have slept for many years in the ground, and yet retained its germinating power. In a similar manner there appeared suddenly, near the old mines of Mount Laurion, in Attica, the plants *Glaucium serpieri* and *Silene juvenalis*, plants entirely unknown, or at least never seen, in that neighbourhood. These seeds had lain buried for an indefinite length of time three yards below the surface, and were brought to light by the workmen who were preparing to extend the mines. This long sleep of the seeds, a sleep which it is thought may last for centuries, explains how it is that tunnellings and railway cuttings are often the scenes of valuable discoveries of new and rare plants; the seed buried for years in the earth being unintentionally and unconsciously dug out by the hand of man. Other plants follow the courses of rivers and running streams, by which their seeds are carried down into suitable places. Thus the *Œnothera biennis*, a native of Virginia, is said to have reached Padua in 1612, and spread thence throughout Europe; and this flower is much more abundant on the shores of the middle and lower Rhine, than in the adjoining sandy plains, which are equally suited for its growth.

Another example is given by the *Collomia grandiflora*, a herb belonging to North America, which was suddenly found in the year 1855 on the banks of the Ahr, near Ahrweiler. It is not known how it reached the spot, but in 1857 it was found already at the mouth of the Ahr, and in 1862 on the banks of the Rhine, near Bonn; so that in the course of seven years it had spread along forty miles of the river banks, notwithstanding the unwearied efforts of the students of Bonn to uproot it and transfer it by handfuls to their herbaria. Animals are of great use in furthering the distribution of plants. Very many fruits and seeds are carried bodily away by being caught and fastened with thorns or brambles in the fleece of woolly animals; the seeds of many Australian plants, for instance, have been carried to Europe in the fleece of Australian sheep. Many animals eat berries without destroying the seed, which passes through them uninjured. The seed so sown is so far from having lessened its powers of fructification, that, in the opinion of Altum, it must have been specially intended to be prepared for sowing in that manner. It is known also that, to the great annoyance of the Dutch trading company, the pigeons who fed on the valuable muscat nuts in the Molluccas, transplanted it with increased powers of germination, increased by its passage through their bodies, although it is said to have previously defied every method of artificial cultivation. The seeds of the white thorn do not germinate until they have lain buried in the earth for a whole year; but if turkeys are fed with the seed in autumn, and the birds' manure sown, the seeds will come up in the following spring.

There is no doubt, then, that many plants have been distributed in this manner by the aid of birds. While some plants spread abroad to almost incredible distances in the course of time, others seem bound to one narrow home; for instance, a member of the palm tribe (*Lodoicea sechellarum*), which grows only on two of the Seychell islands. Its fruits are often carried by the ocean currents to the Maldives, where they are known as Maldive nuts, and their great size and mysterious appearance on the shore gave rise to numberless fantastic suppositions, until their true home was discovered. One of the most effectual barriers against the complete and wholesale intermingling of plants is the sea; for although its currents tend to spread them abroad, its great extent hinders their passage to the opposite shore. The greater the distance between two coasts, the more sharply sundered is their vegetation. Next to the sea, the great desert wastes, such as that of Sahara, act as barriers, and the inaccessible forests of tropical America divide the floras of the adjoining countries. In ordinary cases, however, the changes of climate are sufficient to preserve the distinct character of the natural flora, and the high peaks of mountains, like those of the European Alps, form a limit to the exchange of neighbouring vegetation.

Animals are far less restricted than plants in their wandering propensities. Many of our largest mammals are able to rove through whole continents without meeting any serious physical hindrance. The elephant is nearly as much at home on the mountains as on the plains; it can climb even the highest point of Adam's Peak at Ceylon, a height so steep and rocky that it is ascended by human beings with great difficulty; it crosses rivers with ease, and tramples down a path through the densest jungle. There seem to be no limits to its powers of locomotion, except those arising from the necessity of procuring food, and of remaining in a suitable climate. The tiger can cross rivers, and has been known to swim across arms of the sea, in order to pass from one of the Sunda Islands to another; and it can withstand the severe cold of Tartary and the north of China, as well as the heat of the plains of Bengal. Other animals are more impeded in their powers of dispersal. Apes, lemurs, sloths, and squirrels, for instance, are so exclusively fitted for forest life, that they cannot possibly flourish where there are no trees, and are never found far beyond the boundaries of forest vegetation. On the other hand, wastes and open plains are necessary for the well-being of the camel, the zebra, and the giraffe. Next to great climatic changes, seas and high mountains present the greatest obstacles to the dispersal of animals. As an example of the latter, almost all the insects, birds, and mammals on one side of the chain of the Andes are of different kinds from those on the other side. But even rivers and valleys may serve as barriers for the distribution of animals. In the great valleys of the Amazon, many kinds of apes, birds, and even insects, are found on one side of the river, without attempting to cross to the opposite shore. Thus, along the lower course of the Rio Negro, a monkey and a short-tailed ape (*Jacchus bicolor* and *Brachyurus couxiou*) are found on the northern, but never on the southern shore of the river, where we find only the red-bearded tailed ape *Pithecia*. Higher up the river, but only upon the northern shore, is the *Ateles paniscus*, and on the southern shore the *Lagothrix Humboldtii*.

At first sight it seems as if the dispersal of birds was practically unchecked; but this is by no means the case in fact. The stormy petrels and gulls are some of the best of migratory birds, but they are strictly confined to one or other of the great oceans. A large number of sandpipers and plovers breed in arctic regions, and migrate as far as India and Australia, or as Chili and Brazil; but the types of the old and new continent are generally different. Besides such reasons as determine the powers of dispersal possessed by different tribes, such as a sufficiency of food, suitability of climate, soil, and vegetation, we have to consider the presence of enemies which threaten either the parents, the eggs, or the young birds. In the Malay Archipelago, doves are most plentiful where there are no monkeys, and in South America these birds are proportionately rare in the wooded plains, where we find numerous monkeys and apes, who hunt for the eggs and the young birds. The doves take refuge accordingly in open plains and mountain plateaus, where the hostile quadrumana are rare. If we turn to consider reptiles and amphibia, we find that, with the exception of sea-turtles and sea-snakes, they are scarcely better fitted than mammals to cross the seas and oceans. Even the fishes of the sea meet with checks in their powers of dispersal: the temperature of the water is an impassable barrier for many kinds, and the migration of solitary fishes is of little importance. The herring, which is an inhabitant of the deep seas, comes in the breeding season to the shores of the North Sea; the salmon forsakes the northern seas for the rivers to lay the spawn in the clear, cold water near the source. Mollusca, with their shells, and cockles, spread abroad much farther than we should be inclined to think possible. In their adult condition their movements are extremely slow, but their young ones are tiny creatures, which can be carried by floods and currents to the apparently most inaccessible places. The fresh-water molluscs have yet another means of spreading. Their dwelling places in ponds and marshes are constantly visited by aquatic birds of every kind, which very often carry away, together with the seeds of water plants, insects and eggs of mollusca. It has been observed in an aquarium, that fresh-water molluscs, which had just crept out, hung on to the foot of a duck, and water beetles have been caught, and found to have young living molluscs adhering to them. Moreover, certain species of these animals, especially land snails, are extremely tenacious of life; they have been known to live for two years and a half enclosed in a pill-box; and an Egyptian desert snail was found to be alive after it had been gummed down for four years to a tablet in the British Museum. Winged insects are, as a rule, furnished with more diverse and effectual means of dispersal than any other highly organised creatures. Many of them are able to fly over immense distances. In the year 1844, a swarm of locusts, extending for many miles, and flying as thick as the flakes of a violent snowstorm, visited Madeira. They had come from a distance of three hundred miles, and as they did not cease flying when they reached the island, it is evident that they were by no means exhausted. Many insects are carried to great distances by trees which float down great rivers, as they do every year in thousands along the waters of the Amazon, Mississippi, Orinoco, etc. Doubtless some of these insects are carried to places where they perish for want of sufficient means of existence. The winds which carry away volcanic dust and ashes for hundreds of miles, and the storms which pass in circles over the ocean, are quite capable of carrying a few insects to far distant lands, where they can become the progenitors of a new group of forms. Then the difficulty arises how to explain the wide differences between the insect fauna of different lands and continents. But we must not forget that, as Wallace pointed out, insects are, more than any other creatures, dependent on special conditions of life, without which their existence is impossible, many of them being actually restricted to one spot alone in nature; so that on the whole the hindrances to their dispersal are almost as great as the ways and means of attaining it. For example, there are hundreds of kinds of butterflies which can only live as caterpillars on one kind of vegetable; so that even if the most perfect insects were carried into other parts of the world, the perpetuation of the race would be dependent upon the presence of this one plant. Other insects require succulent vegetable food all the year through, and are consequently restricted to tropical countries; others can only live in forests; others only in deserts; others are dependent upon aquatic plants; and others, again, upon mountain vegetation.

If we briefly gather up all that we have said concerning the distribution of animals and plants, we shall no longer be surprised at the immense extent over which certain species are dispersed, or at the very limited range accorded to other species; we shall be able to take into account and to balance the influence of aids and hindrances, friends and foes, of each separate existence, and so to find a satisfactory explanation of the dispersal of both plants and animals from the central points of their origin; but it is quite another matter to search out and establish these centres of animal and vegetable life, and one which will doubtless occupy for a long time, and perhaps with little result, the careful research of the naturalist.

Distribution of Organisms on the Earth's Surface.

We are accustomed to divide the earth, with reference to its plants and animals, into districts of vegetation and zoological zones. This division presupposes the fact that the separate tracts of land or sea possess a certain uniformity with respect to their organic life. If, for example, in the different parts of Australia we were to meet with totally distinct species of plants and animals, or if all kinds of animal and vegetable forms were well represented in every part of that continent, we could not (supposing that the condition of other countries was not strikingly different) speak of a characteristic Australian flora or fauna. But any one who compares, either in a herbarium or in a conservatory, the plants of the northern parts of Australia with those of the southern, will at once perceive the affinity between both the floras, and will also recognise that the flora of New Guinea must belong to a totally different zone of vegetation. We do not mean to say that the floras of north and south Australia agree in every particular, as, to give one instance, it is only in the northern parts of the continent that we find palms; but we do mean that on the whole it is as allowable to speak of an Australian flora, as we speak of Englishmen, Frenchmen, or Germans. If we consider the uniformity of race only, and not political or individual differences, there is even less difference perceptible between the fauna of the two parts of the continent, and we are therefore justified in saying that Australia belongs to one district of vegetation and one zoological zone. Whether or not any other countries belong to the same district will depend on the organic life of those countries; for the present we will state that Australia itself forms one district of vegetation and one sub-region of zoology. We may therefore claim, not only for Australia, but for every large division of the earth, a certain botanical and zoological character, based upon two important circumstances, the partly local and partly climatic analogy in the construction of the types; in other words, that not only do those organisms which have the same home shew affinities to each other, but also that those which exist under a similar climate shew the same affinities. These two circumstances must be clearly distinguished; there can scarcely be greater climatic differences than those produced by the changes of temperature perceptible in ascending heights from a warm and sheltered valley, and the differences find their expression in the altered character of the mountain and valley flora. And yet the products of the highest regions are often found to be most closely allied to those of the valley from which the mountain rises. The traganthus plant (*Astragalea*), which is found in an almost inexhaustible number of species in the steppes of the East, is represented on the peaks of Taurus, as well as in the warm plains of Asia Minor; the types are distinct, it is true, but they are so near akin, that even their separate subdivisions occur in both climates: in one place spending the greater part of the year buried beneath the snow, with scarcely time for their leaves and fruits to unfold and ripen in the scanty amount of heat vouchsafed to them; and in the other bearing the heat of a rainless summer, and completing their period of development wet with the winter rains in the months of spring. This is the analogy of locality. Although upon the Alps the aspect of nature near the line of perpetual snow represents in many respects the climate and the vegetation of the Arctic circles, yet even its most characteristic plants suggest the thought that they must have climbed upward from the valley, modifying their organisation only so far as was necessary to adapt it to their new conditions of life, and secure their power of existence. They behave like varieties produced by climate, only that they differ from the form which may be regarded as their type in proportion as the difference of climate is greater. But they can neither be artificially produced by culture, nor do we meet those transition forms which we might expect on a gradual ascent; suddenly, at different limits, the Alpine plants appear, and the flora of the plain is lost. The origin of these local analogies existing under such diversities of climate seems to lie hidden in the palæontological secrets of the past, and to be wholly removed from the influence of forces now in action. Very frequently, perhaps generally, the analogy of locality is also one of climate, because the climate of adjoining places, situated at the same height above the sea, is seldom altered to any considerable extent. But there is also a climatic analogy wholly independent of local nearness, when kindred varieties of the same class or classes of the same species appear in widely separated parts of the earth, where the climate is the same. Organisations which correspond to this description have been called *representative* or *vicarious* types. Well-known examples in the temperate zones are the beeches of Japan and of the Straits of Magalhaen, the plane tree of the East and of North America, and the heaths of the Cape and of western Europe. Such an affinity, independent of nearness, and dependent upon climate, agrees with the supposition that the construction of organisms is the result of the physical conditions under which they are produced. We must add a caution, to the effect that representative forms are not such as abound in one place, and are wanting in another; but such as are of kindred organisation: for instance, it is a common but erroneous notion that classes together, as slightly modified forms of tropical life, toucans and hornbills, flamingoes and humming-birds, even tapirs and elephants, euphorbia and cactus; whereas, for naturalists acquainted with the fundamental differences of construction existing between them, the wonder is that such widely different types can be found existing in what is apparently one and the same climate.

It does not appear singular to many of us that heaths, for instance, are found both at the Cape and in the west of Europe; for we are easily inclined to believe that kindred plants are found in similar climates; and that, *e.g.*, we should expect to find heaths, if not everywhere, at least at certain heights upon the Andes, the Himalayas, and Mount Atlas. This is, however, not the case. If the whole area upon which a certain plant or animal is found in its wild state as its home is taken, we shall find that it seldom consists of many totally separate regions, if we assume that islands are to be counted as belonging to their neighbouring isles and nearest mainland. And it would be also incorrect to imagine that we shall only have to deal with local and climatic analogies. The equatorial parts of Africa and South America, for instance, are very similar as to their climate; both are covered with luxuriant forests, and yet there is a wide difference between their animal productions. Instead of elephants, apes, leopards, guinea-fowl, and touracos, we meet here with tapirs, jaguars, curassows, toucans, and long-tailed monkeys. Again, certain parts of South Africa closely resemble Australia both in soil and climate; yet in the one place we find lions, antelopes, zebras, and giraffes, and in the other kangaroos, wombats, mice, and phalangers. In the same way certain districts of North America and Europe are very much alike in all the essential conditions of soil, climate, and vegetation, and yet the former possesses racoons, opossums, and humming-birds, and the latter moles, hedgehogs, and fly-catchers. The facts connected with the distribution of larger and more important groups are just as striking. Marsupials are found from Van Diemens Land in the temperate zones, to the tropical islands of New Guinea and the Celebes, and in America from Chili to Virginia. South America is the only place on earth where there are no crows. There are no antelopes anywhere but in Africa and Asia, and no sloths except in South America; true lemurs are seldom found anywhere but in Madagascar, and the bird of paradise is restricted to New Guinea.

THE DISTRIBUTION OF PLANTS.

Geographical manuals divide the earth into five zones—a tropical, two temperate, and two frigid zones. The very names of these divisions indicate the temperature prevailing within their limits, and as we have seen that certain degrees of temperature belong to the essential conditions of vegetable life, we must expect that the five zones will exert considerable influence upon the geography of plants. These five zones, however, are not sufficient to characterise all the divisions of the vegetable kingdom, and according to Meyer's system each hemisphere is divided into eight zones of vegetation, of which we append a short description.

Northern Polar Zone.—In this zone, which extends from 90° to 70° N. lat., animals, shrubs, and trees are altogether wanting. The scanty covering of vegetation is composed of small hardy plants not more than a few inches in length, with creeping roots and large blossoms.

Northern Arctic Zone.—(Lat. 72° to the northern arctic circle.) Characterised by shrub-like plants. The limit of tree growth falls generally within this zone.

Northern Sub-Arctic Zone.—(From the arctic circle 66° 32′ to 58° N. lat.) This division has no strongly marked characteristics of its own, but has been rightly termed a "transition zone," in which the arctic flora exists side by side with that of more temperate climates. Prevalence of coniferæ.

Northern Cold Temperate Zone.—(58° to 45° N. lat.) The special characteristics of this zone are tracts of deciduous-leaved forest trees, meadows, heaths, moors, and steppes. On the northern limit the beech is seen, and corn is cultivated.

Northern Warm Temperate Zone.—(45° to 34° N. lat.) Trees and shrubs, with stiff, shining, evergreen leaves, and plants armed with thorns and prickles, appear in this zone.

Northern Sub-Tropical Zone.—(34° to tropic of Cancer.) A second transition zone. Growth of coffee, cotton, rice, tea, and maize.

Northern Tropical Zone.—(From the tropic of Cancer to 15° N. lat.) Equatorial produce of all kinds. It contains sugar-canes, bananas, yams, maniocs, patatas, pepper, plants, indigo, rice, and maize. In this zone plant life depends no longer upon temperature, but upon the distribution of moisture, which produces in one place deserts, and in another impenetrable forests.

Equatorial Zone.—(15° N. to 15° S. lat.) In this zone vegetation reaches its highest point of development.

The eight southern zones correspond in their extent and productions to those above given. There are several slight variations, however, in both these particulars, and the south polar zone can scarcely be reckoned at all, since every kind of vegetable life ceases below 65° S. lat.

Similar changes to those presented to the student of botanical geography, as he journeys from the equator toward the pole, are also met with in an ascent from some tropical valley to the snow lines of great mountains; but in this case the divisions are termed regions instead of zones. Ascending from the level of the sea, we pass through the eight regions of palms and bananas, of tree fern and figs, of myrtle and laurel, of evergreens, of deciduous-leaved trees, of coniferæ, of Alpine roses, and, lastly, of those mountain plants which struggle for existence along the limit of perpetual snow. It need not be insisted upon that the lowest region is always identical with that of the valley from which the mountain rises. But this division is more ideal than real, and nature will not be regulated by the neat precision of the systematizer. So difficult, indeed, is it to characterise accurately the regions of our great mountain masses, that even in the Alps, which have been the special field of botanical research, it is only possible to determine with precision three regions, deciduous-leaved trees, coniferæ, and Alpine plants. Kabsch states that the first of these regions extends to the centre of the beech-tree limit, but his theory does not agree with the following table of statistics drawn up by Schlagintweit :—

Upper limit of growth.	Northern Alps.	Central Alps.	Groups of Mont Rosa and Mont Blanc.
Vine	470 yards.	565 yards.	865 yards.
Walnut	790 "	850 "	1,030 "
Beech	1,325 "	1,220 " (!)	1,500 "
Corn	845 "	1,255 "	1,475 "
Trees. Coniferæ.	1,725 "	1,880 "	2,035 "

The variations are still more strongly marked in the extreme heights; for instance, cherry trees grow in the Matterthal at a height of 4,200 feet; walnut trees in the valley of Lauterbrunnen at 3,100 feet; corn at Zermatt to 5,100, and barley even as high as 6,100 feet.

Another method of classification adopted in botanical geography, and based upon our statistical knowledge of the vegetable kingdom, was first employed with good success by the Danish naturalist, Schouw. He started from the assumption that at the beginning of vegetable creation there existed a number of centres of vegetation from which plants were dispersed in radiating movements; the productions of each centre mingling at its outer limits with the vegetation of the adjoining centres. It is an established fact that for many families of plants such centres actually exist, and Schouw drew up twenty-five vegetable kingdoms, over each of which he placed as its ruler the name of a celebrated botanist who had made a special study of the particular plants by which the kingdom was characterised. The veteran authority, A. von Humboldt, did not approve of this classification; he argues that it is the co-existence of different organic forms, and not their preponderance or exclusiveness, which characterises a flora. After the removal of the most important errors, twenty-three of Schouw's divisions are still accepted by Kabsch, as shewn in the following table:—

1. Wahlenberg's kingdom.—Saxifrages and mosses, or alpine-arctic flora.
2. Linnæus' kingdom.—Umbelliferous and cruciferous plants, or north European and north Asiatic kingdom.
3. Decandolle's kingdom.—Labiatæ and the pink tribe, or inland flora.
4. Michaux's kingdom.—Asters and golden rod, or northern North American kingdom.
5. Pursh's kingdom.—Magnolias, or southern North American kingdom.
6. Kampfer's kingdom.—Camellias and celastrineæ, or Chinese-Japanese kingdom.
7. Roxburgh's kingdom.—Spice plants, or Indian kingdom.
8. Wallich's kingdom.—Indian high lands.
9. Chamisso's kingdom.—Oceanic region. South Sea Islands, between the tropics.
10. Forskal's kingdom.—Balsam trees, or Arabian kingdom.
11. Delile's kingdom.—Sahara and north Arabia.
12. Adanson's kingdom.—Tropical African kingdom.
13. Jacquin's kingdom.—Cactus and pepper plants. Mexico and South America to the Amazons.
14. Bonpland's kingdom.—Upper Mexico.
15. Humboldt's kingdom.—Kingdom of cinchona. Eastern slopes of the tropical Andes.
16. Ruiz and Pavon's kingdom.—Calceolaria and eskallonia. The Andes above 2,055 yards over the sea level.
17. Swartz's kingdom.—West Indian kingdom.
18. Martin's kingdom.—Palms and melastomacæ. South America, east of the Andes, between the equator and the tropics.
19. St. Hilaire's kingdom.—South America, exclusive of the Andes, from the tropics to 40° S. lat.
20. Urville's kingdom.—Antarctic kingdom. Patagonia, Terra del Fuego, and Falkland's Islands.
21. Thunberg's kingdom.—Stapelia and Mesembryanthemeæ. South Africa, from the tropics to 35° S. lat.
22. Robert Brown's kingdom.—Eucalyptus. Ultra-tropical Australia and Van Diemen's Land.
23. Forster's kingdom.—New Zealand.

"If we cast a glance," says Humboldt, "upon the different kinds of plants, we recognize among their countless numbers certain chief types to which the rest can be referred for classification. To determine these types upon the individual beauty, distribution, and grouping, of which the *physiognomy of the vegetation* of a given country depends, we must not—as is done in botanical systems from other and necessary reasons—have regard to the hidden organs of fructification, on flower petals or fruits, but we must consider whatever gives by its mass and prevalence the characteristic impression of the landscape. Among these chief types of vegetation we find, of course, whole families of the so-called natural systems. Bananas and palms, casuarinaceæ and coniferæ, appear singly in the botanist's classification. But the *physiognomist* or artist is forced to combine a number of plants which the botanist separates. Wherever vegetation is considered in masses, outlines, distribution of leaves, and formation of stem and branch blend together. The painter [and here the great naturalist will be supported by all the artist's fine taste and feeling] distinguishes in the background of a landscape a beech tree from pines or palms, but scarcely from other forest trees nearer akin to itself. The physiognomy of nature can be divided into sixteen types of plants, or, as we will call them, forms of vegetation."

Griesbach has adopted Humboldt's famous classification to the wider requirements of modern science, retaining the nomenclature of the different forms.

To avoid further explanations, and give an idea of the different forms of vegetation, we append Griesbach's table :—

I. Trees.

A. *Single stem, without branching foliage. Crown of leafage at the summit.*

1. Palms. Trees with leaves of one division.
2. Fern trees. Trees with leaves of several divisions.
3. Bananas. Trees with broad, undivided leaves, the veins running parallel with each other.
4. Claviga (Theophrasta) form. Trees with undivided leaves, broad, and network of veins.
5. Pandanus form. Simple, undivided leaves, narrow and sedge-like.
6. Xanthorræa form. Trees with undivided, narrow, grass-like leaves, containing little sap.

B. *Single stem, without crown at the summit. Tufts of leaves springing from the sides of the stem.*

7. Bamboo form. Trees with grass-like leaves springing from short branches on the stem.

C. *Branching crown of foliage.*

8. Coniferæ. Trees with stiff, evergreen, undivided, needle-shaped leaves.
9. Laurels. Trees with stiff, undivided, evergreen leaf, broad and glossy.
10. Olive form. Trees with stiff, undivided, evergreen foliage, leaf narrow.
11. Eucalyptus form. Foliage stiff, evergreen, and undivided. Leaf broad, dull, and bluish green.
12. Sycamore form. Foliage stiff, periodic (changing once a year), undivided.
13. Beech form. Trees with pliant, periodic, undivided foliage, broad leaves.
14. Willow form. Trees and shrubs with narrow, pliant, periodic foliage, undivided leaves.
15. Lindens and Bombaceæ. Leaves digitate (hand-shaped) or rounded, with veins.
16. Ash and tamarind form. Single feathery leaves.
17. Mimosa form. Trees with double-feathered leaves.

D. *Stems with mutually united crowns.*

18. Banyan form. Trees with roots growing downward from the crown, penetrating into the earth, and sending up fresh growth, which unites with the parent stem. (*Ficus indica*, etc.)
19. Mangrove form. Trees whose fruits germinate while still attached to the branch that bears the fruit. The radicle and crown gradually lengthen and strike root, while leaves are unfolding at the other end. (*Rhizophora*, etc.)

E. *Shrubs branching from the ground.*

20. Heath (*Erica*). Needle-shaped leaves, stiff and evergreen.
21. Myrtle form. Foliage stiff, evergreen, leaf small, glossy green.
22. Oleander form. Foliage stiff, evergreen ; leaf larger than No. 21 ; stiff, glossy green.

23. Proteaceæ. Foliage stiff, evergreen ; leaf dull bluish green.
24. Sodada form. Foliage stiff, periodic.
25. Rhamnus form. Foliage pliant, periodic.
26. Thorny shrubs. Leaves checked in their development by the formation of thorns.

F. *Foliage hindered or wanting.*

27. Casuarina form. Leafless trees. Branching weeping trees, with short, toothed, ribbed sheaths instead of leaves.
28. Cypress and tamarisk form. Shrubs and trees. Branches with very small, close-lying leaves.
29. Spartium form. Shrubs without leaves, or with leaves checked in their development.

G. *Trunkless, woody plants, without branches.*

30. Dwarf palm or cycad form. Crown of divided leaves, on shortened or suppressed stem.

II. SUCCULENT PLANTS.

31. Chenopods. Herbaceous plants with succulent leaves.
32. Agave form. Succulent, leafy rosette, without stem.
33. Cactus form. Leafless succulent plants.

III. CLIMBING PLANTS.

34. Liana form. Woody climbing plants, with net-worked veining in the leaves.
35. Palm Lianas. Woody climbing plants, with palm leaves.
36. Convolvulus form. Climbing plants, without wooded stem.

IV. EPIPHYTÆ (Plants which grow on others).

37. Lorantheæ. True parasitic plants.
38. Orchids (*atmospheric*). Herb-like plants sitting on other plants, but not drawing their nutriment from them.

V. HERBS.

A. *Leafy stem.*

39. Herbaceous plants. Shrubs and underwood. Perennial herbs whose stems turn to wood on the ground.
40. Gnaphalium form. Herbs with woolly covering.
41. Everlasting form. Herbs with leaves gradually drying up.

B. *Bare (or two-ranked foliage) stem. Leaf rosette on the ground.*

42. Bulbous growths. Perennials from bulbs.
43. Scitamineæ, or aromatic form. Foliage in a rosette, or two-ranked. Leaf undivided, broad, with parallel veins.
44. Aroideæ. Leaf rosette, of arrow or heart-shaped, or divided leaves with stems.
45. Bromelia. Reed-like leaves, spiny at the edge or point.

C. *Ringed spore cases growing on the back of leaves. No stems.*

46. Ferns. Leaves or fronds, with spore cases on the back.

VI. GRASSES.

47. Meadow grasses. Grasses with pliant leaves, or blades.
48. Desert (steppe) grasses. Grasses with stiff blades.
49. Savannah grass. Tall grasses.
50. Annual grasses. Grasses with no turf-forming ramification.
51. Cyperaceæ. Stem without joints.
52. Reed grass. High growing stem with leaves growing far apart.

VII. FLOWERLESS PLANTS.

53. Moss form. Green leaves.
54. Earth lichens. Leafless plants, not green.

With respect to the varieties of vegetation which impart to any landscape its peculiar stamp of individuality, we need say but little, for most of them are well known to Europeans. And, besides the familiar aspect of meadow, marsh, moorland, heath, scrub, forest and tilled land, we have received a more or less accurate idea of the Arctic tundra, the Indian jungle, and the Australian bush, or an oasis. Of these latter we shall have more to say in another chapter; for the present we will finish this part of our subject with the table of botanical regions drawn up by Griesbach, and based upon an accurate study of the different types of vegetation, and their connection with the variations of climate.

Their boundary lines are laid down with sufficient clearness as follows:—

1. Region of Arctic flora. Characterised by the short time allowed for vegetable life, and the comparatively low temperature prevalent during this period. The plants belonging to it must endure a wintry sleep of at least nine months. The polar limits of the forests form the south boundary of this region.

2. Forest region of European Sibera. Characterised as to climate by the uniform average heat prevalent during the three months of vegetable growth, uninterrupted by long droughts.

3. Mediterranean region. Chief among the characteristics of this region are the dryness of the summers and the mildness of the winters. While in the forest region the highest development of plant life coincides with the warm time of the year, the plants here are developed during the spring, remain quiescent during the dry season, and revive again under the influence of the autumn rains.

4. Region of the steppes. Severe and long winter, followed by a short spring and dry, hot summer, which passes over without any transition to the snows of winter. In this region vegetable growth is only possible in the spring.

5. Chinese-Japanese region. Rainy season brought by the monsoons in the spring of the year. Great regularity in the course of the seasons.

6. Region of the Indian monsoons. No special climatic characteristics. Tropical vegetation and climate.

7. Region of Sahara. Rainless region of the uninterrupted trade-winds.

8. Region of Soudan. The beneficent rainfall occurs as a rule only when the sun's rays fall vertically on the earth, and consequently vegetation enjoys only an intermittent development.

9. Region of Kalahari. Rainless intermediate region between the true desert, the steppes, and the savannas.

10. Region of the Cape. The climate here closely resembles that of the "terrace landscapes" of Spain; in both places great varieties of vegetation are fostered by the unequal distribution of heat, the yearly rainfall, and the amount of atmospheric moisture.

11. Australian region. In North Australia, tropical climate, with rainy period in summer. Belt of desert round the circle of the tropic where the trade-winds reign supreme. In Australia, winter is the only rainy season, and in Tasmania rain falls in every season.

12. North American forest region. Same as European Siberian forest region.

13. Prairie region. Severe winter, followed by short period of vegetation, ushered in by transient rains, and followed by a dry, rainless summer. The extreme drought is caused by the dryness of the westerly currents of wind, from which all the moisture falls on the Californian coast ranges and the Rocky Mountains.

14. Californian coast region. Uniform temperature, with a difference of a few degrees only between summer and winter, and regular alternation of a moist, cool summer with a dry summer; in a word, a true sea climate.

15. Mexican region. This region is divided into three zones, according to their elevation above the sea level—the Gulf zone, the Pacific, and the intermediate highland zone. Tropical vegetation and climate.

16. West Indian region. Two rainy seasons in the year, when the sun is in the zenith.

17. South American region (this side of the equator). Large forests along the coasts and river banks, in consequence of the tropical heat and moisture. In the interior, sudden contrast of dry and wet seasons, producing the savannas of Guiana and the boundless llanos of Venezuela.

18. Region of equatorial Brazil. Forest region created by the uniform tropical heat and constant accession of moisture from the banks of the Amazon, Orinoco, etc.

19. Region of transequatorial Brazil. Colder than the preceding region. Prevalence of regular rainy seasons.

20. Pampas region. South of the zone of tropical rains.

21. Region of the tropical Andes of South America. Vegetation dependent upon the height above the sea level and the rainlessness of the Pacific coast.

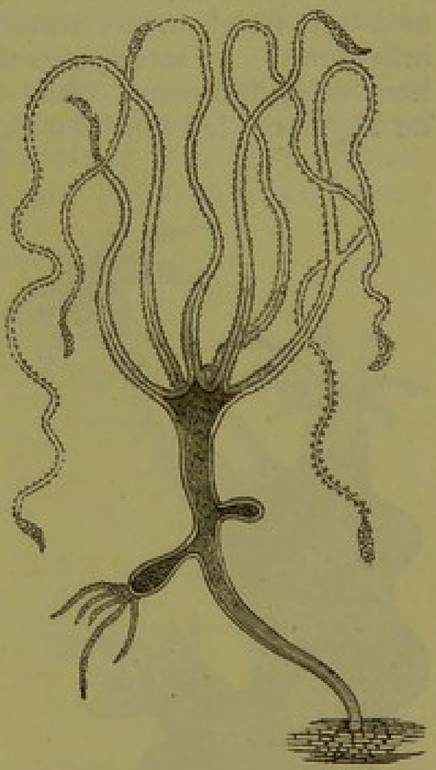
22. Chilian transition region. Climate resembling that of the third region, but the drought which interrupts the vegetation lasts more than six months.

23. Antarctic forest region. Atmospheric rainfall distributed over the whole year. Mild winter, as a rule.

24. Oceanic island region. This region preserves the original arrangement of plants in the greatest purity; and as the indigenous growths often vary considerably from those of the mainland, it was from the study of this island flora that the theory of centres of radiating vegetation and plant migration arose; so that this region, insignificant in local extent, is most important to the student of natural history.

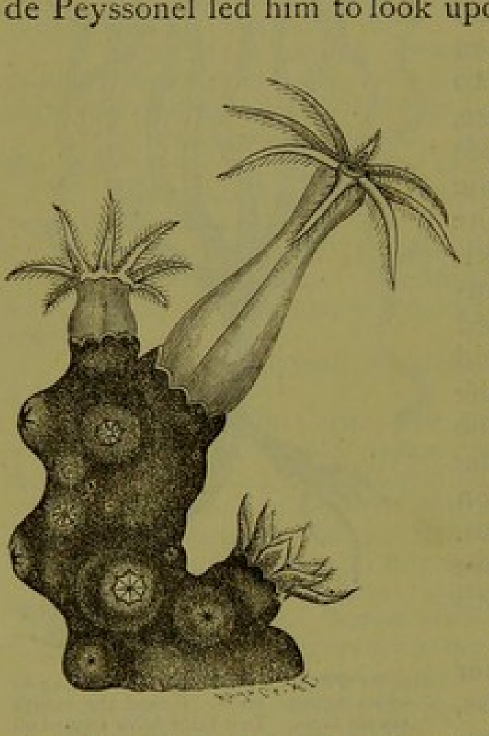
THE DISTRIBUTION OF ANIMALS.

Among the manifold phenomena which unite in making up the general character of each different portion of our globe, it is not always those which arrest our attention at the first glance which are able to retain our interest longest, or excite it to its highest pitch. The grand outlines of mountain ranges, the blue of the sky, the form of the cloud masses, the transparency of the air, and the luxuriance of vegetation—any one of these things attracts us at once by the important effect which it exercises upon the whole scene, while the animal world retreats to the background; and by the small number and size, or the rapid movements of its members, escapes observation. But when once observed, when the majestic silence of the woods is broken by the swift passage of the deer, or the tap of the woodpecker against the trunk of some tree, the attention of the naturalist is more thoroughly aroused than it had been by any of the still life around him. There is no need to draw up tables of the different types of animal life, as we have done for vegetable growths; for the structure of the animal is closely connected with the position assigned to it by science in the animal kingdom. In place of different systems of vegetation, we have to consider the social life of animals with members of their own class.



BROWN POLYPUS (*Hydra fusca*) resting on on an aquatic plant. Round the mouth are six arms. Two buds have formed on the side of the body, an older growth on the left has already put out two arms Another younger one on the right. (Enlarged size.)

The tie which unites one animal to the other members of its kind is unequal in its closeness. The lowest organisms (not to speak of the protozoa) are generally sexless. The animal is self-sufficing, and does not seek out its fellows for purposes of the reproduction of living forms. In stagnant waters overgrown with weeds it is easy to procure a specimen of the hydra. Let plants be spread out there in a large quantity of water, and examine, with the aid of a magnifying glass the lower side of a leaf, and there will be seen hanging from it a tiny green or brown creature, which generally stretches out its six or eight arms to capture any living animalculæ which float past it. This hydra perpetuates its race by putting forth what looks like a bud issuing from the stem of a plant; the bud is a living creature, which after a while detaches itself from the parent stem, and leads an independent existence. Many animals propagate their species in a similar manner, except that while the offspring of the hydra separates itself from its producer, the offspring of the corals remain attached to the place of their birth, just as the buds of a branch form part of the whole organism of the tree. On a superficial observation, indeed, the whole family of corals, sponges, and similar creatures appear to form part of the vegetable kingdom, and science recognises their curiously complex origin by giving them the name of zoophyte. The finer forms of coral were for many years looked upon as plants, and yet the substance, so much admired for its delicate colour and high polish, is nothing but the inner skeleton of a formation, once overgrown with living animals, appearing as a pale pink gelatinous substance, arranged in raised heaps, each of which contains a living creature shaped like a small white cylinder, flecked with red, and having at its upper opening eight flower-like arms, which it can extend or draw in at pleasure. Can we wonder that the ancient civilized nations on the shores of the Mediterranean Sea, in which alone the corals are found, were at a loss how to understand these mysterious creatures; or that Ovid, the poet of the Metamorphoses, speaks of it as a tree, which in the water is soft and pliant, and in the air rapidly hardens into stone? In later years the coral was spoken of as a wonderful rock which bore living blossoms. And when at length the patient investigation of André de Peyssonel led him to look upon the coral as an animal, and to communicate his discovery to the French Academy, his theory met with so little support, that Réaumur thought it kind to suppress the name of the bold theorist, lest it should injure his scientific reputation. There can be obviously no social life, in the higher sense of the word, among corals and similar zoophytes. Each animal lives or vegetates alone, caring nothing for his neighbours, and yet unconsciously contributing his quota to their existence; for all the food consumed by one member is destined to feed the whole number, and passes through the minute channels which intersect the rocky mass; the nutritious juices flowing out of one body into that of the nearest animal. And the results attained by this social life, if it may be so called, are truly astonishing; whether we contemplate the immense coral reefs built by the tiny creatures in our own days, or whether looking back to their far greater labours in past geological ages, we find ourselves forced to ascribe in a great part to their agency the present surface formation of the globe on which we live. We see them protecting low-lying coasts from the surging breakers, and building up huge masses of rocks, which threaten our ships as sunken reefs, and later appear above the surface of the ocean as islands. The silent work is carried on sometimes with great rapidity; for a sunken ship in the Persian Gulf was found to have been incrusted with a coating of coral, twenty-six inches thick, in the space of twenty months; and in the Torres Straits, where, in the seventeenth century, there were only twenty-five coral islands, there are now a hundred and fifty.

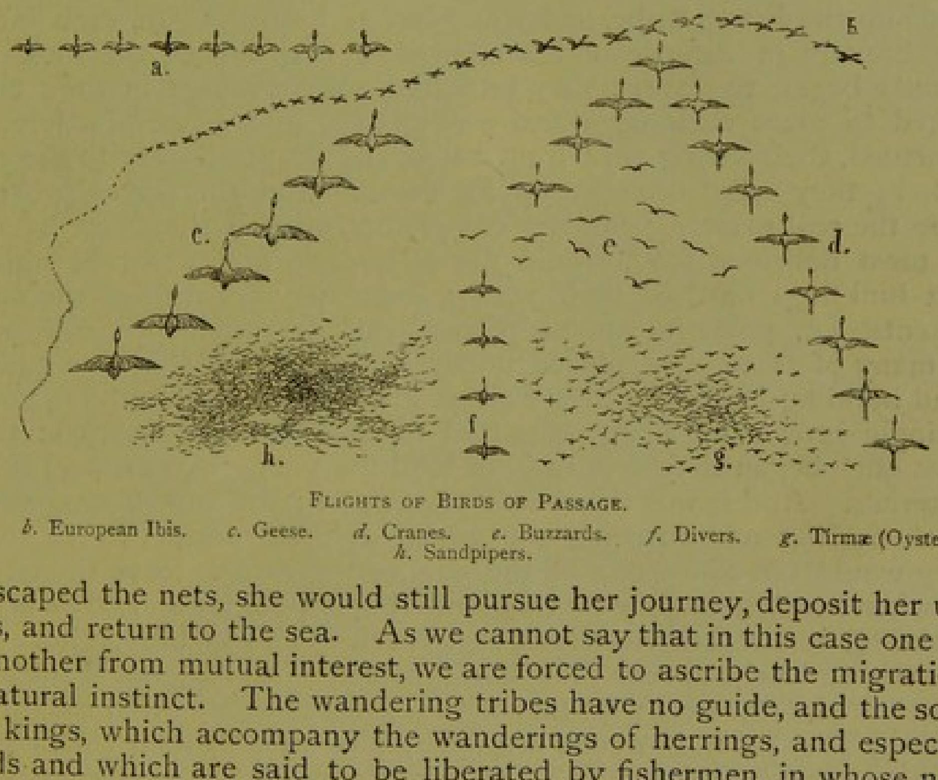


Part of a Coral Formation, with one fully developed Animal, and two partially developed. (Enlarged size.)

Animals uniting two sexes, or hermaphrodites, are found among stationary animals, such as oysters, and slow-moving creatures, as worms. The hermaphrodites do, however, seek each other out occasionally. Spiders are generally considered to be the most unsocial of living beings; and yet, in spinning webs at the pairing season, the male and female of certain kinds dwell in, or rather under, the same cobweb. The male approaches the female (which is generally much the larger and stronger of the two) with slow and cautious advances, as well he may; for if she is unfavourably disposed to him, he runs the risk of being summarily devoured. The female, it is true, deposits her eggs in a sheltered place, but beyond that she pays no heed to her maternal duties. This, however, is not the case with all spiders; there are certain species whose females carry their eggs about with them in a little pouch spun for the purpose, and only leave them under the stress of urgent danger.

The care so sparingly bestowed upon their offspring by spiders is developed to a very high degree in other animals, whose social life is not intermittent, but constant.

There are two reasons which seem to cause the social life of animals, one is the so-called social instinct, and the other is an extension of an extremely careful attention to the needs of the young by the parent. We will consider the former case first. It is well known that in the spring several kinds of fish set out on their migrations to deposit their eggs; some of them come in large shoals from the sea to the rivers, as, for instance, the salmon trout in the Rhine. Thousands of them fall a prey to expectant fishermen; but even if the female



FLIGHTS OF BIRDS OF PASSAGE.
a. Ducks. *b.* European Ibis. *c.* Geese. *d.* Cranes. *e.* Buzzards. *f.* Divers. *g.* Tirmæ (Oyster catchers). *h.* Sandpipers.

alone escaped the nets, she would still pursue her journey, deposit her unfruitful eggs, and return to the sea. As we cannot say that in this case one animal seeks another from mutual interest, we are forced to ascribe the migration to a blind natural instinct. The wandering tribes have no guide, and the so-called herring kings, which accompany the wanderings of herrings, and especially of pilchards and which are said to be liberated by fishermen, in whose net they are found, lest the shoal should miss the services of a leader, are not even akin to the herrings, but accompany them only for the purpose of preying upon the helpless shoals. The case is not very different with respect to the migrations of birds of passage. When the wandering flocks set out in autumn for the distant homes, where life will be made possible for them through the winter, many species, such as swallows, migrate in flocks, and observe some sort of order in their flight. But leaders and guides there are none: each bird seems only intent on its own safety; and it often happens that the mother-bird leaves her half-fledged young to perish, lest she should be too late to join the flight of the tribe.

In these instances the social life of the community is caused by the separate necessities of the individual; but there exists a far higher kind of social existence, in which great undertakings are carried out by individuals for the good of the community. First among the rank of social animals are certain kinds of ants and bees. Ants are divided into three kinds, male, female, and working, or undeveloped female ants. A division of labour is made between the three ranks; the working ants having all the responsibility of supporting the community. It is they who build the wonderful structures found under ground or in hollow trees, and intersected by curious galleries and corridors. The red ants of the European forests are the most famous builders in our continent, and their dwellings are often more than from three to four feet above the ground, and of still greater extent below. Inside these dwellings, which are composed of the most various products of the pine woods, a curious and busy life goes on. There is in one sense perfect equality, each individual of the same class doing the same work, no class ruling another, but all possessing equal rights, notwithstanding the singular relations existing between them and their slaves and house friends. It happened that a tribe of amazon ants (*Polyergus rufescens*), very common in the south of Europe, but not unknown in the Rhine valley, inhabited a building, or rather a city, near to a tribe of brown ants (*Formica fusca*). Suddenly a troop of amazons advanced on the brown tribe, and a murderous battle began, each individual fighting bravely in defence of his comrades. At length the ranks of the brown ants began to waver; they retreated, sought refuge in their city, and attempted to place their eggs and young ones in a place of safety. They were pursued, their young torn from them, and dragged away to the enemy's city, where they were brought up as slaves. But the slaves proved after all to be the real masters; for the conquerors, even if they were surrounded by the most delicious food, would die of hunger, and never be able either to erect buildings or tend their young, since they are without the necessary instruments, *i.e.*, powerful mouth-pieces, used for such peaceful purposes. When many of them were placed under a glass, together with a quantity of food and building materials, they were soon found to be in a dying condition. But a single brown ant being admitted to them, all was changed: the new-comer at once began to feed the adults, tend the young, and arrange the building materials. And it was the same out of doors; the brown ants were seen acting as nursing and carrying the young of their masters in the sunshine; but they would not allow one of the conquering race to leave the city alone, except when it was necessary that a plundering expedition should be organised. When the robbers return victorious, they receive them joyfully, relieve them of their booty, and help to rear their own kinsmen as slaves; but if the amazons return defeated, they meet with no such reception, but are often roughly thrust out again. The latter, however, are splendidly loyal to their rulers when the city is threatened by misfortune; they strive eagerly to save the lives of their young charges, and of the adults. And now we have to speak of the ants' friends and visitors. We know that any intruder who ventures within the ant city is exposed to furious attacks on the part of the inhabitants, but it is not so commonly known that a number of creatures are actually admitted by the ants as friendly inmates. Thus the ants frequently drag wood-lice into their dwellings, or build round a company of the latter animals with a heap of earth and other materials, carrying their young ones into the building, or making a covered passage between their house and the dwelling of the wood-lice. They are attracted by the sweet honeyed juice which the latter yield from time to time from minute tubes on their back. The ants may be seen stroking the

VULTURE, CHAMOIS AND MARMOTS.

wood-lice with their feelers, and obtaining in return for their caresses the desired juice. Still more intimate is the friendship existing between the yellow ant and the yellow beetle (*Claviger testaceus*). The latter is blind, and would die of hunger without the aid of the ants. When the two insects meet, the beetle eats out of the open mouth of the ant, as the young pigeon does out of the crop of the old bird. In return for this aid the beetle gives the ant a draught of sugary nectar contained in a tuft of yellow hairs at the back of its wings, and no ant meets one of these beetles without licking the tuft of hair. These are only two instances of the many friends possessed by the ants; in Germany alone they are known to have three hundred out of all classes of insects. While on the subject of animal friendships, we may mention one which often furnished the ancients with an instance of loyal truth and fidelity. The soft-shelled crab (*Pinnotheres*) dwells between the shells of several sea mussels, especially the *Pinna*; the mussel provides a safe home for the defenceless crab, and the latter, by means of its sharp eyes, warns the mussel of coming danger. The more scientific and less sentimental view of the close friendship is that we have here an example of the union of two animals who live upon the same kind of food, or that the mussel is only sought out by the crab because it possesses a strong house in which the latter finds shelter.

If the social instinct is developed among the ants chiefly with respect to their intercourse with other animals, it is the very life and essence of the communities of bees. Three kinds of bees are found in every hive—a queen, some hundred drones, and several thousand working bees. The queen is the only female, the drones are males, and the working bees hold the same rank as the workers among the ants. Their duty is to produce wax, build the cells, collect honey and pollen, and do all the household work. The drones, true to their name, do no work, and are driven out of the hive in autumn. The queen is the object of the love and care of all her subjects, who are for the most part her own posterity. They offer her the choicest food, stroke and caress her, and are spurred on by her presence to exert themselves in every part of their service. It is her part to lay eggs and increase the numbers and power of the community. She is the life and soul of the hive; and if she is lost without leaving a successor, the whole community is broken up, work is at an end, death is the fate of many members, and exile of the remainder. The latter become a wandering pirate horde, penetrating into foreign hives to rob them of their honey, and meeting the fate of such invaders—the usually peaceful inhabitants rising *en masse* to expel them. But very often the working bees are able to avert the threatened calamity. When the hive contains the larvæ of working bees, the adult workers enlarge the cells and feed the young with nourishing food, strengthening them until they reach their full development, and appear as queens and heads of those who have chosen and nourished them. But only one female is able to reign within the hive; the queen allows of no rival at her side. As soon as the first of the new queens breaks from the egg, and announces her arrival by a peculiar "tooting," great commotion arises in the hive, a restless coming and going, humming and buzzing; the work is at a standstill; every member is conscious of the coming crisis. Some of the bees forsake their sovereign, and range themselves round the royal aspirant to the throne. The queen-mother cannot endure this desertion, and flies away with those of her subjects who remain loyal to her, to found a new community. But the new queen is not left in undisturbed possession of her rights; for, as a rule several royal sisters are ready to dispute the throne with her. In that case there is a duel *à outrance*, and the conqueror retains the throne.

In such well-ordered communities as we have been describing, we see that social life has made a great step in advance from the mere aimless flocking together of shoals of fishes or flights of locusts. But there is yet a higher development of social life, in which we see the strong element of caste overcome; where every member is independent, and yet all feel that they *are* members of a community, and bound to obey its leader. A tribe of long-tailed monkeys reconnoitres an orchard or field of fruit trees, their leader at their head. He advances slowly, looking cautiously round, climbing up the crests of trees, and keeping a good look-out. Every member of the expedition has perfect confidence in his prudence; his footsteps are marked by all; the branches and twigs which he seizes are seized by all, at the very place where he touched them. At last the wished-for goal is reached, and every one falls without restraint upon the tempting fruit; the leader alone is not suffered to forget his duties. From time to time he looks round and explores the ground; suddenly he interrupts his feast, and by an indescribable sound, half cry, half whistle, he gives warning of impending danger. In a moment the ranks are formed; the young flee to their mothers; a wild retreat begins, and is continued until the tranquilizing tones of the leader assure his followers that the danger is past. His is the stern autocracy of a tyrant, whom all must obey: the strongest arm and sharpest teeth are the qualifications for the office, which is always filled by a male, and is most eagerly sought for, in spite of its restraints and duties. Something of the kind exists among the wild horses of the Asiatic desert; the strongest stallion is the leader of the herd, and each leader jealously guards and watches his troop. At times it happens that a member of another troop tries to drive away a mare belonging to his rival, and his attempt is the signal for a deadly combat, the infuriated animals rearing up on their hind legs like bears, and savagely falling with all the power of their teeth on their antagonist. Overcome at last, the weaker yields the prize to the victor.

Among some animals the qualities demanded of a leader are age and tried prudence, and in this case a female is sometimes found at the head of the herd, especially among elephants. The most absolute obedience is demanded, the subjects following their chosen guide, even if he lead them to utter destruction.

It is not surprising that animals which have attained this degree of association should band together for purposes of self-defence against the enemy; that while the females and the young take to flight, or crowd together in trembling herds, the males should advance in battle array to meet the foe, attacking with powerful horn, sharp tooth, or crushing hoof. The power for defence and attack of such united herds is greatly dreaded. In the plains of the Ukraine and little Russia every house is fenced round with walls of thorny plants, fourteen to sixteen feet high, to protect them against the attacks of wolves. Night after night these beasts of prey prowl round the herds of cattle on the steppes. They approach the wild horses with great precaution, hoping to seize on some undefended foal straying too far from the herd; for when the horses recognise the foe, they rush upon him boldly, striking out with their fore-feet, and generally laying him lifeless with a single blow. Even a large number of wolves cannot rout a herd of wild horses. Brehm relates an instance of loyalty and *esprit de corps* among monkeys. "One of the fiercest African birds of prey," ~~he tells us, "~~ is the hawk-eagle. He pounces down upon the most savage squirrel without scruple, and bears it aloft, caring nothing for its sharp teeth and spitting; but he seldom ventures to attack long-tailed monkeys. As I was hunting one day in the forests, I suddenly heard overhead the rush of the pirate's wings, and a moment later a fearful screaming among the monkeys. The bird had made a swoop down upon a young, but independent member of the tribe, and was trying to carry it off to a safe place, where he could devour it comfortably. But he reckoned without the assent of the clan. The monkey, when seized by the bird, clung so desperately to the tree on which he was seated, that the eagle could not carry him off. At the same moment a terrible uproar broke out among the herd, and the pirate was instantly surrounded by about ten strong apes. With shrieking yells and hideous chatterings and grimaces, they rushed upon him, and seized him on every side. Letting go his intended prey, the eagle thought now of nothing but his own escape. But this was not so easy. The monkeys held him tight, and would probably have strangled him, if he had not torn himself loose with a tremendous effort, and flown swiftly away, leaving clouds of feathers from his wings and tail flying about in the air. It may be certain that the routed assailant will think twice before he ventures to attack another monkey, and draw down upon himself such a burst of fury."

The benefits received by living under this kind of rule are fully recognised by the animals themselves. If an elephant happens to be separated from his own herd, he tries to join another company; but he is generally looked upon as an unwelcome intruder, and driven away with blows and thrusts. He persists, however, for a long time in his endeavours, and only when finally repulsed does he sink down into one of those solitary wanderers, or rogues, which are so justly dreaded. The herd of elephants wander peacefully through the woods, always avoid men, and never attack them, except in the extremity of danger; but rogue elephants are so dangerous, that they are hunted down in India, and no one will have them even in captivity—so thoroughly does a solitary unnatural life sour and change their mild and peaceable disposition. We might adduce many similar instances of social life among animals, but we will pass them by as presenting nothing very different from the examples we have given. And we need not do more than mention the strange union which exists between many animals and their living parasites.

The distribution of the separate animal types, and their most important centres of creation, are expressed in the various zoological regions. The closer description of the divisions will be found later on; their limits are given in the subjoined table by Wallace.

We find upon it six zoological regions, each of which is divided into four subdivisions. There is no arctic region corresponding to that of the arctic flora, because the number of representatives of arctic mammals and birds is too small, but we shall find the whole polar region treated together with reference to its fauna and flora; for the animals of the region—glutton, lemming, reindeer, polar bear, arctic fox, eider duck, auk, and looby—are important to the inhabitants, and interesting to the geographer. In determining the regions, regard has been had to statistical considerations, as well as to geographical particulars, and the relative animal wealth of the regions is made clear in the following arrangement :—

Regions.	Vertebrata.		Mammals.			Birds.		
	Families.	Special Families	Genera.	Special Genera.	Per-centage.	Genera.	Special Genera.	Per-centage.
Palæarctic Region	136	3	100	35	35	174	57	33
Ethiopian ,,	174	22	140	90	64	294	179	60
Oriental ,,	164	12	188	55	46	340	165	48
Australian ,,	141	30	72	44	61	298	189	64
Neotropical ,,	168	44	130	103	79	683	576	86
Nearctic ,,	122	12	74	24	32	169	52	31

These zoological regions do not coincide with the botanical regions, and still less with the political divisions of any country; but it has often been noticed that the botanical and zoological *subdivisions* coincide.

We must call attention to one more point, namely, that, in drawing up the tables of zoological and botanical regions, the starting point was in each case strictly scientific, and therefore great, if not exclusive, stress has been laid on circumstances which are of less importance in a work like the present, where animal and vegetable life is regarded chiefly from a geographical point of view. Zoologically, it is of the highest importance to know that there are moles in Europe, but not in North America; that there are no crows in South America, and other facts of the like nature; but a work on physical geography need do little more than notice such particulars, and in the following pages we shall see fit several times to deviate from the strict scientific divisions which we have given above.

CHAMELEON (*Chamæleo vulgaris*). Length 10 to 12 inches.

CHAPTER II.

ASIA.

NORTH ASIA.

THE north of Asia projects everywhere into the treeless region of the arctic flora. On this side of the desolate arctic solitudes, where long nights and dreary plains of ice threaten the life of all vegetation, a wide belt of forest land encircles the whole circumference of the northern hemisphere. Before the two continents were inhabited, both the eastern and western were covered in their higher latitudes with this ring of forests. With civilization began the clearing of the woodlands from the Atlantic coasts. In Europe, where the Hercynean forest presented to the cultured Roman some such pictures of primeval nature as the backwoods of Canada offer to the European settler of to-day, this transformation of the original vegetation has long ago reached its limit, and found to the north and to the east an impassable barrier in the inclemency of the climate. In later times the same processes are repeated in the forest belt of North America, and enable us to form a good idea of the aspect of Europe in past ages. In the great woods of Siberia and British America, in the hunting grounds of the fur-bearing animals, the primitive type of vegetation is found existing in all its purity, and we find it easier to recognise the extent of its necessary conditions of life there than if we studied it in more cultivated lands. We mention this to shew why we begin our studies of plant and animal life in Asia, instead of in our own continent of Europe.

In the south, this northern belt of forest, as we shewed in our table on page 412, is sharply defined by sudden climatic transitions; but its immense longitudinal extent from France to Kamschatka excites our amazement, as we are naturally inclined to look upon Siberia as the most terrible of lands. And yet it is impossible to divide this vast region into more closely limited natural floras, for the physiognomy of the landscape is nowhere suddenly altered, and the change called forth by the gradual transition from the coast climate to that of the mainland is based not so much upon new types and formations as upon the regular appearance and disappearance of the component parts of the flora. Kitlitz's studies of Kamschatkan vegetation shew clearly how closely the character of the landscape scenery of the extreme eastern part of Siberia corresponds with that of Europe. The plains and slopes of the mountain chains are for the most part covered with noble forests, broken by meadow land. As in the forests of northern Scandinavia, the birch is the king of the trees; but toward the centre of the peninsula we find a crossway tract of coniferæ in which the fir and larch are well represented, and the wealth of vegetation growing at their feet is of the same type and character as that of Scandinavia. Even the willow trees found by the morasses of western Kamschatka recall the flora of the Russian marshes, not to speak of the fact that the number of the European types represented in eastern Siberia amounts to more than thirty per cent. of the whole number of organic plants.

The climate of Siberia is decidedly a continental or land climate. The extremes of its summer and winter temperature occur near the Lena, and Jakutsk is the arctic pole of the eastern hemisphere. The ground is frozen to a depth of more than 600 feet; but as the upper strata thaw sufficiently in summer, the subterranean ice has no ill effect upon vegetation, and even agriculture is successful in these cold regions. It has been called in question by Kohn whether the ground of the tundra is really frozen, but Brehm and Count Waldburg-Zeil have established the fact beyond all doubt. Dove has shewn that the Atlantic Ocean exerts its mild influence over the whole of Europe as far as the Ural Mountains, which keep back the warmed currents of air from passing over into Asia. In Siberia the Pacific Ocean has little power to soften the sharp contrast of summer and winter, and exerts an influence worthy of notice only in Kamschatka. A mountain chain which encircles the Gulf of Okotsk, far beyond the mouth of the Amoor, prevents the moist ocean wind from penetrating into the interior, and even the summer temperature on the coast is lowered by the extent of the drifting masses of ice. Lastly, the warm south-west winds of South Asia cannot enter Siberia, for they are met by the highest mountain ranges of the globe, and the lofty plateaus which connect or lie before them, and draw from the atmosphere every particle of heat before it is able to reach Siberia.

The surface of Siberia, with respect to its covering of vegetation, presents marked contrasts. Along the northern coast is a band of tundra, varying in width from 180 to 340, or even to 550 miles broad, consisting of tracts of land covered with mosses, lichens, and dwarf vegetation, often interrupted by stretches of absolute barrenness. Then comes a vast extent of forest land, principally composed of birch and coniferæ in the north and highest points, and of deciduous-leaved trees in the south and the sheltered valleys. The greatest extent of the forest is found from Lake Baikal toward the north, where the woods are more than 1,200 miles wide. In the south-west, on the banks of the Irtisch, the region of the Siberian steppes may be said to begin, although there are already within the forests many desolate tracts resembling steppes. The terribly severe climate, and the violent storms which occur almost as often in summer as in winter, are hostile to animal life; but although, thanks to these unfavourable influences, we cannot expect such a rich fauna as in more temperate climates, yet the country is of such vast extent, and such great variety of form, that it comprises a very considerable and interesting array of animal types.

We will begin our survey with the tundra.

TUNDRAS.

The explorer Finsch tells us that a journey across the tundra can be accomplished by the aid of reindeer only; and that moreover the traveller will need the services, not of ten or twenty animals, but of whole herds. The preparations for a summer journey have to begin months beforehand; for instance, if it is wished to go to the north-west of Siberia, arrangements must be made with the owners of reindeer herds at the yearly fair of Obdorsk.

Finsch and his companions, Brehm and Von Waldburg-Zeil-Trauchburg, though they knew well what a tundra means, yet being unacquainted with the details of such a journey, undertook it on foot. The travellers had turned their backs upon the tree line, and found themselves a little to the north of Obdorsk, near the river Ob, whence they intended to cross the tundra to the gulfs of Obi and Kara. The word tundra means "treeless region," and recalls the appellation, barren grounds or wastes, given to similar tracts of land in North America. As far as the eye can reach, it meets with nothing but an endless plain of dull brown or whitish yellow moss, or surfaces of monotonous green, covered with the stunted creeping shrubs of the dwarf birch. Barren chains of hills of a pale grey or dun yellow accord well with the colourless tones of the landscape. The only relief is found in the scattered tarns of various sizes, surrounded with their fringe of shrub willows from twelve to forty-eight inches high. But the traveller's feet are tired out even sooner than his eyes, thanks to the unusual demands made upon them. The foot never treads on firm ground ; at every step it sinks up to the ancle, and has to be disentangled with an effort from the clinging tendrils of the dwarf birch. The only method of walking is to lift the foot very high at every step, a proceeding which soon becomes extremely wearisome. Very often the path lies across boggy places, where the pedestrian sinks up to the knee, or is obliged to spring cautiously from one tuft of grass to another ; in short, the construction of the ground presents every possible hindrance to rapid and easy walking. Such is the moss tundra, where the ground is moist and treacherous, overgrown with *Polytrichum* (maiden-hair) and *Sphagnum*, or turf moss. Isolated patches of cotton grass (*Eriophorum*), and rushes (*Luzula*), which are found scattered among the mosses, although green themselves, lend scarcely any variety of colour to the scene, because they are almost hidden by the mossy cushion, and the faded yellow leaves only reach the surface of the expanse of yellowish moss. Here and there, however, the grasses get the upper hand ; blades of two to four inches long shoot up, and among them are seen the blossoms of the Siberian flowers, *dryas* and *Cassiope*. This formation, so fully developed in Sibera, is not found in North America, where the nearest approach to it is the "lichen tundra."

The second day which Finsch and his companions spent on the tundra opened with the promise of a welcome surprise, for they came upon the recent tracks of reindeer and sleighs. Soon afterward they came in sight of a herd grazing, and before nightfall they had reached it. The owner came to meet them in great state, with two large sleighs drawn by reindeer. Apart from the novelty of the sight, the reindeer troika is a very handsome and imposing vehicle, and the travellers anticipated no little pleasure in continuing their journey in the sleighs instead of on foot. A bitter disappointment, however, awaited them ; for an enemy, against whose attacks all human power is unavailing, had invaded the tundra. An epidemic had broken out among the herd. They counted eighty dead beasts on their way to the camp, and the sight when they reached it was even more pitiable. Waldburg, who, as a rule, was not lavish with his cartridges, fired right and left ; the Ostiak had begged him to shoot down the young ones which could not be reached by his lasso, for the mothers were already dead of the plague, and the skins were the only valuables left in the herd, now reduced from two thousand to five hundred animals. The price of the smooth, dark-brown, long-haired skin of a reindeer calf is, upon the tundra, from nine to ten shillings. As the camp was about to break up, the travellers were obliged to follow. On the next halt the Ostiak ordered one of the largest deer to be slaughtered ; but the repulsive method of preparation, and the sight of dead bodies of the diseased animals which covered the plain, deprived the travellers of all desire to partake of the meal. The difficulty of obtaining fuel on the tundra makes anything like civilized cooking impossible. The fearfully rapid course of the plague, which is yet little understood, is truly appalling. Animals, apparently in robust health, stop still, begin to snort and pant and shiver, cross their fore-legs, and fall down dead. Sometimes death follows the first symptom in less than three minutes, but generally the agony lasts longer, often even an hour. In the latter case the poor creatures run wildly round, as if driven wild by pain; try to enter the tents, stumble, and drag themselves up again, fall at last, and die with strong convulsions of the extremities, or motionless. The young escape the contagion; it is the weaker animals among the females which succumb first. It is piteous to see the young ones running wild among the herd to find their mothers, and uttering a peculiar cry of distress. In the year 1865, this disease carried off 150,000 reindeer between Petschora, Ob, and Zenesei; numbers of the dwellers in the tundra lost their all, and the wealthy owners of large herds were reduced to absolute beggary. Another plague to which the herds often fall victims is the foot disease. Our travellers bought nine of the strongest animals, all apparently untouched by the disease, and continued their journey in three sleighs. Anything like a beaten track is of course out of the question, except that made by the lemmings and arctic foxes for their private use. The tundra regions of north-western Siberia present, on the whole, the same characteristics, and are chiefly distinguished from those of east Finmark, by the absence of chaotic piles of rubbish heaps. The tundras of Lapland are covered with moss, and abound in patches of dwarf birch. In these latitudes vegetation is developed with incredible rapidity. "The warm showers," says Raffmonn, "which fell on the 20th of June, effected a fairy-like change in the scene; the larch trees sent out their fresh leaves in a few hours, and the young foliage of the dwarf birch covered the ground with a tapestry of green."

The fauna of the tundra is very scanty. It is seldom that more than five couple of arctic ducks, or two or three divers (*Colymbus glacialis*), are found on any of the pools, although some of the latter are of considerable size. Toward the end of July these inhabitants of the plains and their young saved themselves by swimming and diving to the centre of the tarn, where they were out of range of the guns. Their danger signal, "ah-oo, ah-oo," sounds almost melodious in comparison to the harsh cry of the arctic ducks, which is like the wailings of a beaten child, and breaks the silence very unpleasantly. Other sounds, like the creaking of a wheelbarrow, are often heard, together with the long-drawn melancholy "tu-ut" of the sandpiper, which is heard almost all day long, the mew-like "pi-ow mi-ow" of the buzzard, flying high overhead, and the harsh grating whirr "err-rek-ek-ek-ek" of the frightened willow grouse (*Lagopus albus*). Such are the voices of the tundra, harsh, wild, and plaintive, according well with its wild solitudes. Geese are rarely seen, and never except at a distance, and the travellers only noticed solitary gulls or sea swallows in the interior. Along the sea-coasts, dwarf or mountain sand-snipe and game-cocks are found, and among the marshes the barking cry of the arrow-tailed, predatory sea-gull (*Lestris parasitica*) and its kindred type (*Lestris pomarina*) is heard, and becomes one of the characteristic marks of the tundra. The *Lestris pomarina* is a noble bird, so tame that it can be approached within fifteen paces, and in its flight resembling the falcon. Unfortunately its flesh is uneatable, so that the leaders of the expedition were obliged to devote their attention principally to the sandpipers and ptarmigan, whose destiny it was to furnish the principal part of each day's food. Every one was obliged to be his own cook; that is, hold his own bird, spitted on a thin rod, and turn it about before the fire, after it had been plucked and carefully cleaned. If the travellers succeeded in getting a good bright fire, and attended diligently to their duties as turnspits, the birds would be found cooked in from fifteen to twenty minutes, nicely browned outside, and filled with juice inside, equal to the cookery of the best hotels. It was extremely interesting to watch the "housekeeping" of the rare birds of prey found upon the tundra; principally the migratory falcon (*Falco peregrinus*) and the buzzard (*Buteo lagopus*). The young falcons are seen perched upon high stones among the grass, for lack of trees, while the buzzards generally erected a large eyrie of dry twigs of dwarf birch. The young ones, mere balls of thick white down, were generally found three or four in a nest, and suffered terribly from the gnats. Not only were their heads, near the beak, covered with these pests, but even the back of the leg was not safe from them. The young birds avenged themselves by a constant snapping up and swallowing of their enemies. The young of the sea-gull were especially clever in this warfare; and both they and the young buzzards knew how to feign death on the approach of a stranger. The falcons, on the contrary, would utter piteous cries, and even the old birds often betrayed the place of their nest by their shrill cries of alarm. They and the buzzards would fly to and fro above the heads of the travellers, sometimes keeping within range of the guns. The eyries of the birds of prey were generally found to contain the remains of lemmings, and the same animals were found in the stomachs of the sea-gulls, while those of the wild ducks contained only a kind of crab (*gammarides*). The crops of the ptarmigan contained nothing but willow leaves. Among small birds, the white and yellow-hammer, mountain larks, finches, and sometimes red-throated field-pipers were seen. Near the larger tarns, fringed with luxuriant vegetation, appeared solitary wagtail, and near the Podorata, blue-throated warblers and water wagtail. The tundra is still poorer in mammals than in birds. Solitary specimens of the wild reindeer are said to be found, but never in any number, except in the wooded region. But wolves are abundant enough to work great damage among the flock. The arctic fox (*Canis lagopus*) was several times heard, but never seen; while the earth mouse (*Arvicola obscurus*) and the lemming (*Myodes obensis*) were frequently met with. This rodent, akin to the mouse tribe, about the same size as the field mouse, but with only a rudimentary tail, is the chief food of the beasts of prey of the tundra, and it is positively declared by the inhabitants, that in winter it is eaten by the reindeer. In spite of their numbers, they were very difficult to capture, as they lie hidden in their branching corridors underneath the roots of the dwarf birch and the moss, although the dogs of the Ostiak did their best to unearth them. The lemmings are of great importance to the dwellers of the tundra, for a good year for lemmings means a good year for foxes. The lemmings, as is well known, set out sometimes on those singular wanderings, which have made the Norwegian species (*Myodes lemnus*) famous. Sometimes they will avoid a neighbourhood for years together, where they were once found in thousands. The peasants of the mountain districts of Scandinavia still believe that the lemming is rained down from the clouds in enormous quantities, and that it destroys its digestion by its gluttony, and so perishes wholesale. But the reports of their migrations abound in fanciful exaggerations, one of which, for instance, is the fable that they eat their way through a rick of hay rather than deviate from the straight line, and that the fishermen are often surrounded by the animals in such numbers as to fill their boats, and sink them. The Siberian lemmings are said to cross the Ural Mountains in large numbers from the end of May to the middle of June. They penetrate as far as the White Sea, and in the autumn they return to the eastern side of the mountains. The naturalist Brehm, who has studied the lemmings in their own home, ascribes their instinct for migration to the scarcity of food. Although they descend sometimes to the plains, they must nevertheless be considered as mountain animals, for the tundra of the far north of Scandinavia has much of the character of the broad flattened ridges of more southern mountain chains. If after a mild winter there come a good spring and a dry summer, all the conditions necessary to the almost boundless increase of the lemmings are fulfilled. But the drought of a hot summer causes also the scorching up or stunting of the succulent plants on which they live; the wide pasture land no longer yields sufficient food for the myriad hungry rodents dependent upon it, and they are forced to seek their pasture elsewhere. In these circumstances, not only rodentia, but other herbivora—antelopes, for

Lemmings Pursued by White Owl and Buzzard.

instance—wander away in flocks, taking their companions with them on the way, and continue their journey at hazard, as they have no fixed direction, nor does any instinct guide them to places where they would really find what they seek. Not until hundreds of thousands of them have perished from hunger, disease, weariness, or accidents, do they return to their own proper domain on the heights, and then it may be that they travel in a straight line. In short, the migration of the lemmings is not more wonderful than that of other migratory mammals, especially earth mice. It is fortunate that the lemmings have so many enemies; for if they were not kept down, they would overrun the whole country, and eat up everything edible. The climate is their most destructive foe. A wet summer, or a cold, early autumn without snow, kills them off by millions, and then it takes long years before the loss is made up. But, besides the climate, the lemming has a number of living enemies. Wolves and foxes pursue them for miles, and as long as they can get lemmings they eat nothing else; the glutton is hot in pursuit of them; martens, hedgehogs, and ermines chase them, and them alone; the hungry

Lapland dogs, who live in a state of chronic famine, look upon a good year for lemmings as a festival such as they seldom meet with; the owls pursue them on their wanderings; the white owl is found almost exclusively where lemmings abound; the buzzards appear to make it the chief business of their life to extirpate the poor creatures; ravens feed their young with them; crows and magpies do their best to devour the delicate morsels; even the reindeer, we are told, eat them, or, as is more probable, when enraged by the pugnacious manners of the little fellows, strike them dead with their fore-feet.

The insect life of the tundra is very poor; Finsch brought home only a few beetles and butterflies, and on one occasion the expedition discovered a bees nest. But the one thing that did flourish was the gnat tribe. In cold nights, like that of the 1st of August, when the thermometer stood only a few degrees above zero, there was a slight abatement of the plague for a few hours, but with the first ray of sunlight, at about two o'clock in the morning, they began again, defying the protection of glove or veil.

How greatly these tormenting little creatures embitter and spoil the journey can scarcely be imagined. If the traveller stands still for one moment to consider his path, may be, or for any necessary purpose, he is covered with thousands and thousands of bloodthirsty gnats, and is stung into a desperate advance. Obliged to keep waving the hand every minute to keep off the hungry swarms, constantly beset by them, stung and fevered, hindered in every enjoyment, checked in every action, disturbed even in thought, the wanderer is worn out, not only in body, but in mind, and is forced to exert his will every moment, that he may not give in in despair. It is no wonder, then, that after a few hours of such exertion he should arrive at every halting place tired to death, and be less and less willing to leave it again; although even here, unless a smoky fire is immediately lighted, the gnats pursue him, and interrupt his slumbers without mercy. If there were no gnats in the tundra in summer-time, one could grow reconciled to its monotony, surmount its many difficulties without murmuring, bear all the hardships and privations which it entails, and leave it with a pleasant memory; as it is, the gnats spoil every enjoyment it has to offer, if not for ever, yet for a long time.

The nights were almost as light as day, and, owing to the absence of gnats, it would have been much pleasanter to travel by night instead of in the daytime, but for the reindeers' sake this was impossible. The unfortunate animals were so plagued by gnats and horseflies (*Hypoderma tarandi*), that they refused to feed in the daytime, and did it only in the cool hours of early morning, when the heavy dews were falling. Moreover, the tundra does not always provide them with their favourite reindeer moss (*Cladonia rangerifina*), and therefore the halting stages had to be chosen with a view to their pasture grounds. The halting stages, indeed, meant nothing more than that, after having cooked an evening meal, everybody wrapped himself up in his furs, and lay down to sleep on the bare ground.

The reindeer never gallops in harness, but advances in a long swinging trot. Three reindeer drawing a light sleigh, with no luggage, and only one passenger, took four hours to run six miles. On sandy, stony, or clayey ground, from six and three-quarters to nine miles are considered to be a day's journey, and the two strong deer only carried a weight of about 130 pounds. The sleighs move very easily over the moss or dwarf-birch tundras; and then a weight of 200 pounds can be carried from about thirteen to fifteen miles in a day, especially if a relay can be got. The case is very different in the winter, when the gnats and horseflies and heat have disappeared, and the reindeer is free to shew all his grand qualities of speed and endurance. A load of 480 pounds may then be entrusted to two animals, and be drawn from nine to twelve miles an hour with ease, if the path is good; indeed, distances of from fifty-four to fifty-eight miles have been traversed on one feed. These statistics we have taken from Finsch and his companions; those given by earlier writers claim a far greater rate of speed for the reindeer. The deer are often found in a wild state in Siberia, and they are accustomed to set out on long regular wanderings. To escape the stinging flies, it leaves the open plains in the summer, and betakes itself to the high wooded slopes, returning again toward winter to the lower grounds. At the end of May, large herds leave the forests, where they have been partially sheltered from the terrible cold, and make for the northern plains, partly because they find better food there, and partly to escape the swarms of gnats and flies which darken the air in clouds every spring. This appearance in the spring brings little profit to the people of the place, for the deer are then very thin, and covered with wounds and boils from the stings of insects; but in August and September, when the herds take to the forests again, they are healthy and well fed, and their flesh is much sought after. They always travel by the same road. When they wish to cross a river, they choose a place where a dry path leads down the valley to the brink of the stream, and where on the opposite side a sandbank makes their landing easier. Each separate herd assembles in one place, and takes to the water, which is soon covered by the swimming deer. The does lead the procession with their kids, the bucks following. The migration is often seen on a large scale, and two herds were observed to be more than two hours in swimming across the Baranicha. The migrations of the reindeer of North America are at least equally remarkable. In the spring they cross the frozen sea to Greenland, where they remain till the end of October, and then return home.

The land of the Ostiaks, Tunguses, Samoiedes, and Buriats, comprising the river district of the giant streams Ob Yenisei and Lena, from 58° N. lat. to the frozen sea, is the burial place of the mammoth (*Elephas primigenius*); the principal places where the remains were discovered are situated on the Lena and the islands of New Siberia. The natives collect the tusks only, which may be turned to account. Finsch was told that in Irkutsk alone from fifty to sixty-five tons come into the market every year, and represent there the sum of about £3,500. The famous skeleton rescued by Adams, and preserved in the Museum of St. Petersburg, shews the colossal size of some of the tusks; and Finsch tells us of tusks four yards long, each of which weighed 292 pounds, while it is considered unusual to see the tusk of an African elephant weighing 150 pounds.

When Adams, of whom we have just spoken, heard that a mammoth had been found with skin and hair complete, he set out at once to save the valuable treasure, struck up a friendship with the chief of the Tunguses who had discovered the animal, and set out to the place where the discovery had been made. The chief had discovered the animal as far back as the year 1799, but had not attempted to turn the circumstance to account, because some of the old people of the peninsula declared that a similar discovery had been made by their ancestors in the same place, and that it had drawn down ill luck upon the finder, whose family had since become extinct. This legend terrified the chief to such a degree that he fell ill; but the enormous tusks of the mammoth proved so attractive to his covetousness, that it gained the victory over his superstitious fears, and in March, 1804, he sawed off both the tusks, and exchanged them for goods of little or no value. Two years later, when Adams reached the spot, he found the carcass still there, but greatly mutilated. The flesh had been torn off to feed the dogs; polar bears, gluttons, wolves, and foxes had fed upon the old-world mammoth, and the skeleton only, with the exception of one fore-foot, remained intact. The head was covered with a dry skin, and the eyes, brain, and one ear covered with bristly hair, were still in a state of good preservation. The soles of the feet were left, and about three-quarters of the skin of the body. The latter was of a dark-grey colour, covered with reddish woolly hairs, intermixed with black bristles thicker than horsehair. The longest hairs found by Adams were on the neck, and measured twenty-eight inches. The thick covering of the whole body shewed that the mammoth was created to live in cold climates. The tusks of this primeval elephant are much more curved, and considerably longer, than those of their modern descendant; some of the tusks describe three parts of a circle. Adams collected everything that he could carry away. Ten people were scarcely sufficient to take away the skin, and the hairs picked up from the ground weighed more than thirty-four pounds. The remains suffered great loss during the long and difficult journey to St. Petersburg; but, thanks to the researches of the daring traveller, the fact of the mammoth's existence is proved once and for all time. It was, perhaps, the contemporary of human beings in Siberia, and it is certain, from the remains of food found in the hollow teeth, that it fed upon conifers.

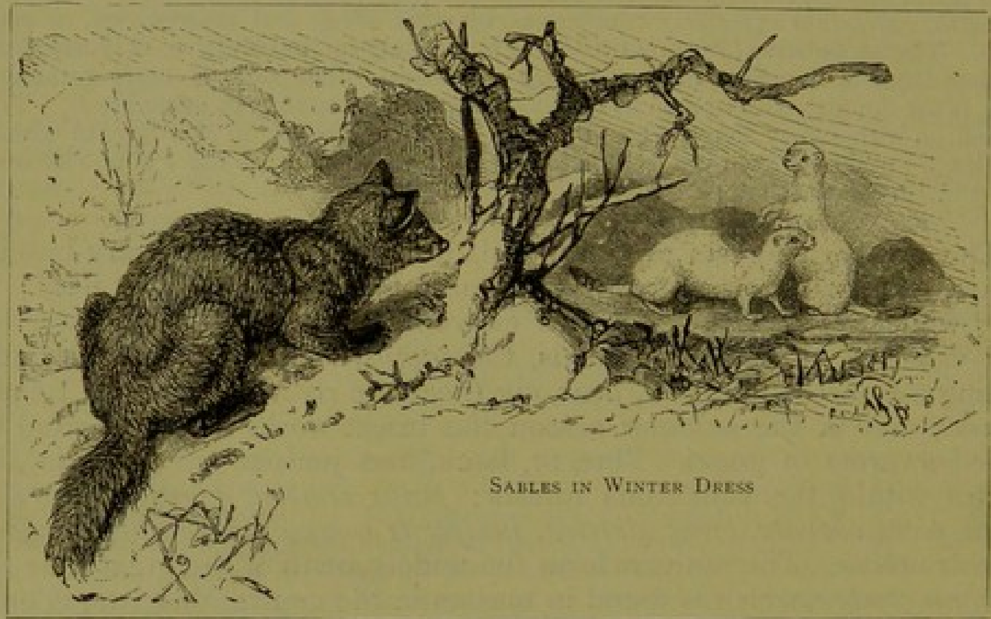
Forests.

Coniferous trees, with an intermixture of birch, are the prevalent types of vegetation, which make up the great Siberian forests. Other trees are found in the south, where the traveller meets now and then with aspens, black and white poplars, and more frequently with mountain ash, willows, alders, and the fruit tree *prunus padus;* but the latter are scarcely to be counted among forest growths. The magnificent woods along the banks of the Ob consist chiefly of pine and fir, mingled with birch and willows, and an undergrowth of mountain ash and *prunus padus.* The mossy soil is covered with numerous berry-bearing plants.

The northern boundary of the forests is marvellously rich in berries, the *rubus chamæmorus,* also found in abundance on the tundras, is the most plentiful, but there are many others, among which we may mention the small but very sweet wild raspberry (*rubus arcticus*), and the heath berries, such as bilberries, or *vaccinium myrtellus;* whortleberries, or *vaccinium uliginosum, vaccinium oxycoccis;* cranberries, or *vitis idæa;* and crowberries, or *empetrum nigrum.* The strawberry (*fragaria vesca*) is found only in the south of Obdorsk, but there is an abundance of fine hips and haws (*rosa acicularis*). The time of berry gathering, says Finsch, is for the girls and women of Obdorsk what the vintage is in other lands. The work is carried on with merry songs, while the men are busy getting in the hay, of which large quantities are obtained from the rich meadows on the left bank of the Polni. This was not the case in Kawalski's time ; that is, in the year 1848.

The northern forests are beautiful, but silent ; only solitary bullfinches, fieldfare, hedge-sparrows, heath-cocks, and a few other birds are heard within them ; while the quadrupeds which enliven their wild solitudes are, besides many valuable fur-bearing animals, the *tamias striatus,* a little creature resembling a squirrel, fox, wolf, bear, elk (near the river basin of the Lena), and reindeer ; and in the summer season the insect world is represented by the dreaded swarms of gnats. Pine, fir, larch, and juniper are found in all their varieties within the coniferous forests ; *pinus cembra, pinus silvestris, abies sibirica, picea obovata, larix sibirica, juniperus communis, juniperus nana,* and *juniperus sabina.* The junipers form the undergrowth of the great pine forests. The *pinus cembra,* which is found in masses in the central districts, is only met with in solitary specimens in the northern and southern frontiers. This tree has a great influence on the life of the squirrel ; for when its cones fail, the animals are forced to set out on their migrations. Among us the squirrel is a stationary animal, whose travels scarcely extend farther than from one end of their wood to the other, but in Siberia it undertakes every year perilous journeys across treeless spaces, over lofty mountains, and even swims wide rivers. In the year 1847, thousands of these little creatures, driven by hunger across the wide waters of the Yenisei, were killed in the streets of Krasnojarsk. They are very clever in going straight to the places where the pine cones are to be found, and it has been said by some naturalists that they are guided by leaders who have been despatched during the summer on special voyages of discovery. The squirrels are not allowed to have the fir cones all to themselves, for the latter are highly prized throughout all Russia for their seeds, which are very good when eaten fresh. They yield a fine oil when pressed, and are as much sought after as hazel nuts among ourselves. At present the chief commercial interest of these forests, of which the valuable timber has not yet been turned to account, is confined to the fur-bearing animals found within them, the sable, pine-marten, ermine, otter, beaver, and squirrel.

The home of the sable extended originally, according to Brehm, from the Ural Mountains to Behring's Straits, and from the southern mountain ranges of Siberia to lat. 68° N., and a small tract of land in North-West America. But every year narrows the limits within which the hunted creature may hope to find safety. Its relentless pursuers never relax in their pursuit, and have driven their prey to the darkest recesses of the mountain forests of the north of Asia. Even here it is exposed to constant danger, and it is consequently becoming rarer and more difficult to capture. In Kamschatka, at the time of the conquest of the peninsula, there were so many sables that the Kamschatdales easily paid their tribute in the skins of these valuable animals, and even laughed at the Cossacks who were so foolish as to give them a knife in exchange for a skin. So numerous, indeed, were the sables at that time, that a merchant could easily gain more than fifty times the price he bartered for the skin in eatables. But a hundred years ago things were already very different, and not a tenth part of the skins were forthcoming. At that time a good skin cost (in Kamschatka) about three shillings, and a bad one scarcely sevenpence, white at the present day the price is sixty or even a hundred times as great. For the sable is fast dying out. In the year 1850, 43,000 skins were brought to the fair at Irbit, and in 1870 the number had fallen off to 5,000. Every year the chase of the sable brings together all the men of many tribes capable of bearing arms, and also attracts numbers of merchants who travel for thousands of miles to obtain the skins. The sables are now found principally in the gloomy forests between the Lena and the east coast;



SABLES IN WINTER DRESS

the hunts lasting from October to the middle of November or the beginning of December. The hardy hunters gather together in small companies on the hunting ground, where each band has its own huts; the dogs are trained to draw the sledges, which are loaded with provisions to last for many months. Then the chase begins. As soon as a sable is discovered in a hole of the earth or in a hollow tree, a net is laid round it, and it is driven from its lurking place, or the tree is felled, and the sable killed with gun or arrow. The aim is, of course, to capture the animal without injuring its skin. The hunters devote several days to setting traps and snares, and very often are doomed to find that a cunning arctic fox or other hungry beast of prey has robbed the snares of the precious contents, and only left a few fragments of fur to prove that the value of six, seven, or even twenty-five pounds has been lost to the hunter. At times the terrible storms of snow or rain force the hunters to devote all their energy to saving their own lives, without daring to wait to take the sables from the snares. In short, the hunt for sables is now nothing but a series of hardships, where the expenses are sometimes covered, but the sufferings are never repaid. Even in Siberia, and at first hand, a skin costs from sixty to seventy-five shillings, and with us the price varies from thirty shillings to twenty-five pounds. The finest skins are found between Jakutsk and Okotsk, and the less valuable ones near the Yenisei, the Lena, and the Amoor. In Siberia, sables are classed as light, reddish, or beech, and dark or cedar sables; the latter kinds are found in the coniferous forests, and are of three or four times the value of the former which inhabit forests of other trees than conifers. One hundred and ninety-nine thousand skins, representing a total of value of £217,500, are sent out every year from Siberia, the north of China, and

North-western America. The Siberian pine-marten is little valued; the ermine, which is found between Ischim and Barabinsk, being considered the best, though this fur, once worn by princes only, has now fallen considerably in price, the value of the whole yearly produce of 400,000 skins being £15,000, or ninepence each only. Otters and lynxes are held in high esteem among the Mongols for the beauty of their fur; a good otter skin commands a price of from sixty to seventy-five shillings, that is as much as the best sable, for which we pay five or eight times the value. This explains easily enough why so few otter and lynx skins are sent to us from Siberia. Beavers frequent the great rivers of northern and central Siberia, and abound even in those streams which flow into the Caspian Sea, but the skin is rather heavy, and therefore of no great value. The animal is hunted principally for the sake of its castor, a dark salve-like substance, with a strong smell and bitter taste, once highly valued as a sedative, but now falling more and more into disuse. Last, but not least, in value comes our friend the squirrel. From the beginning of March to the beginning of April the inhabitants of the banks of the Lena devote themselves entirely to the squirrel hunt. Traps are set by thousands, the most common consisting of two boards and a piece of dried fish, arranged so that when the squirrel enters the trap the upper board falls on its head, and kills it. The Tunguses shoot it with blunt arrows or small-bore guns loaded with balls no larger than a pea, aiming always at the head of the animal. The squirrel hunt in the south-east of Siberia is full of adventure and excitement. The sportsman is well repaid by the number of the game, and his attention is kept always on the stretch by the chance of falling in with some of the more formidable denizens of the forest, such as the tiger or the bear. In the Siberian forests already a squirrel skin costs from fivepence to sevenpence, and this price is doubled at its first market in Irkutsk. The finest skins are known in the market by the name of miniver, and a great number of persons are employed in this branch of the fur trade. From Russia alone more than 2,000,000 miniver skins are exported yearly, principally to China; and yet, such is the extraordinary fecundity of the animal, there are no signs whatever of its becoming rarer. But it is incorrect to imagine that Russia possesses a great wealth in her fur. In the first place, she imports twice as much as she exports; in the year 1870, for instance, the imports were £197,750 against £76,750 exported; and, secondly, she receives more for her pigs' bristle than for all her furs put together, hare skins bringing in more than any other kind of fur.

The forests of the far north seem destined for a wide hunting ground, which agriculture will never win for more peaceful purposes. For it has been clearly shewn by Middendorff, in his explorations in northern lands, that the climatic barriers are reached in this place, beyond which the frozen soil of Siberia checks the growth of agricultural vegetation, wherever the summer's heat is not sufficient to counteract the cold of the other months. The moisture of the earth, chilled by the melted snow, is ruinous to summer and winter cereals, although powerless to hurt the hardy conifers. The northern limit of barley runs as far as the Ob, near the arctic circle, and falls 4° lower to the Lena (61° to 62°), crosses with the mountain range of Okotsk to the river basin of the Amoor, without reaching quite to the east coast, where agriculture is only possible in a far lower latitude, scarcely 50°. The climate near the Gulf of Okotsk does not admit of agriculture, for the heat of the summers is insufficient, and even in Kamschatka the attempts to grow barley have only succeeded in the interior of the country to the extent of producing poor and scanty crops. According to Griesbach, the climatic varieties of cereals have not been made use of there. After the results obtained in Norway, barley seems especially capable of producing varieties which adapt themselves in a wonderful way to the climate. In the short stretch of land between Hardanger and Bergen, the time allowed for vegetation varies from seventy-one to a hundred and forty days; an acceleration of growth takes place between the period of germination and the formation of the ear, while the period between the formation of the ear to the ripening of the grain is the same as it is in Germany. In this sense, therefore, it may be possible to develope agriculture in Siberia; but there is always the risk, and that not only in the northern part alone, that the harvests may be ruined by frost, that no seed is left for a future crop. In certain parts of the country, near the Ob, for instance, the potato may be cultivated a little farther north than barley.

As to the organic life of east Siberia, we are told by those travellers who visited the country in the years 1854-60, taking their journeys almost always during the summer season, that the climate of the region near the Amoor is equal to that of the most favoured parts of Little Russia. Luxuriant foliage, oak, elm, wild apple tree, maple, jasmine, and vine, all combined to give them the impression that the Amoor lands did not yield in warmth and moisture to the lands of the northern Caucasus. But an accurate observation of a series of temperatures soon dispelled this favourable opinion, and we know now that the average yearly temperature of the Amoor lands is from 20° to 28° lower than that of the same latitude in western Europe. These statements appear at the first glance to be contradictory, but the climate corresponding to the average yearly temperature of Torneo is not very injurious to vegetation; because the Amoor lands, in spite of the vicinity of the ocean, enjoy a thoroughly continental climate, with a very long and cold winter, and a temperate and even warm summer. The influence of the desert of Gobi makes itself already felt here; and although there is no monsoon along the Amoor, the wind blows from the sea in the spring, and from the land in autumn. The landscape created under the influence of these several factors has been aptly called park-like, grassy plains covered with creeping plants resembling the convolvulus, tall shrubs, trees, and forests grouped in picturesque variety, which is prevented from becoming monotonous by the special characteristics of the different parts of the country. For instance, the lower banks of the Amoor and the Ussuri are richer in forests than the lowlands of the central Amoor; and near the Ussuri, coniferæ are less abundant than other trees, while they are the only trees found on the banks of the upper Amoor, and are only interspersed with other kinds where the river comes out above Albasin. Long tracts along the centre course of the Amoor and the Ussuri are altogether destitute of forests; for the inundations which take place in April and July, and rise to the height of from six to seven yards, hinder the growth of forest trees, and produce a singular landscape in which all the level ground is covered with coarse grass, broken by marshes and small lakes, and all the rising ground is covered with forests. On the whole, however, two-thirds of the country near the Amoor consists of forest land. The larch holds the first place among the coniferæ, and in the next rank comes pines, firs, and Siberian stone pines; the latter sometimes towering high above its neighbours, like the palm tree in tropical forests. It grows principally on the mountain slopes of Khingan, and its immense quantities of seeds form the favourite food of numberless squirrels. The four kinds of trees just mentioned, and the junipers and yew trees growing among them, make up more than half of the trees found in the country. Among trees not coniferous, we find birches, oaks (*Quercus mongolica*), elm, ash, nut (*Juglans mandschurica*), cork tree (*Phellodendron amurense*), maple, linden, apple and pear tree, acacia, cherry, willow, hazel, aspen, poplar, whitethorn, woodbine, elder, currant, etc., in all more than a hundred species, all of them peculiar to Europe and the Caucasus, and wholly unrepresented in Asiatic Russia. The typical tree of the flora of the Amoor is the *Mongolian oak*. Unknown throughout all Siberia, it grows only in the form of bushes near where the Amoor comes out from the great Khingan chain, and is met with as a lofty tree only in the little Khingan, and on the banks of the Ussuri river. It is never comparable to the European oak, being often hollow, and therefore valueless for practical purposes. The *walnut tree* is the pride of the forests of the lower half of the Ussuri country, where it grows to a height of from sixty-four to sixty-six feet, with a perfectly straight trunk eighty-four inches in circumference; and it is prized the more, because, except in the Causasus, it is found nowhere else in the Russian Empire. The *cork tree* is also a *specialité* of the Amoor country, and may perhaps soon become a useful article of international commerce. The vine is found in abundance on the slopes of the little Khingan and its neighbourhood. As this plant yields a good supply of grapes, even when in a wild condition, it is quite possible that in time the Amoor land may grow its own wines. Too little is known as yet of the different kinds of herbs and grasses of the country to allow of any definite conclusions as to the character of its flora. But we know enough to say with certainty, first, that it contrasts sharply in many respects with the flora of Siberia, and, secondly, that it has much in common with that of the north of Japan, northern China, and even of North America, more especially of California. Out of 846 species from the Amoor lands, which have been classified and belong to only 117 families, more than 150 are found in North America, and about 240 in China. The flora has moreover this peculiarity, that among many plants belonging to the cold temperate zone, some are found belonging to warmer regions, such as orchids, lotus plants, etc. The height and succulence of the grasses in these countries cannot be matched in any other part of Russia, with the exception, perhaps, of Kamschatka. It is not only an occasional, but a constant occurrence to find meadow grass from five to six feet high. For this reason the hay harvest always takes place before the grass is ripe, and in autumn there must either be a second harvest, or the grass must be burnt to allow of the soil's producing a fresh crop in the following spring. When the grass is rotted by the heavy rains, it forms a black soil, often three-quarters of a yard in depth, on which rich harvests of grain are grown. Among the wild herbs, there are many famed for their medicinal qualities, among others the famous ginseng (*Panax ginseng*), a Chinese panacea, found on the banks of the Ussuri as far as 47½° N. lat. Among the plants cultivated from the upper Amoor to Kumara, we find rye, barley, oats, buckwheat, potatoes, cabbage, cucumber, carrot, and radish; along the central Amoor, and near the Ussuri, besides those just named, are corn, millet of several kinds, peas, beans, flax, poppy, tobacco, and here and there Indian corn gourds, but no melons or water melons. These have only recently been cultivated near the lake of Chankai. Along the lower Amoor, especially in the north of Mariinsk, nothing is cultivated but garden stuff and small patches of oats, rye, and barley.

This richness and variety of the flora in the country of the Amoor make that region one of the most valuable parts of Asiatic Russia, especially as its fauna is as extensive as its plant life. Altogether there are known to exist at the present time about fifty species of mammals, especially *rodentia*, *ruminants*, and *carnivora*. The principal rodent is the squirrel, which abounds wherever the *pinus cembra* is found. It is of the ordinary kind, dark grey in colour, and in commercial value holds the next rank to the squirrels of Uosk and Olekminsk. The rats and mice are so numerous, that they compel the natives to build their storehouses on high erections of piles. The white hare is not often hunted, but seems destined to be devoured by foxes and other beasts of prey. Among the latter we find two kinds of bear, a large brown species and a small black bear found in Thibet; badgers, gluttons, on the upper Amoor, and sable principally on the lower Amoor and in Ussuri land, of which from twenty-two to twenty-five thousand skins are exported yearly; red and dark-brown foxes, wolves, martens, ermines, otters, and lynxes; and among the larger felines, panthers and tigers. The latter animal is principally found near the Ussuri and the Amoor, from the crest of the little Khingan to the mouth of the river Gyrin, which forms their north-eastern limit. They prey upon wild and domestic animals, often prowling round human habitations, and committing great havoc. Among the less formidable denizens of the woods are the stag, the elk, the roe-deer, and the musk, as representatives of the ruminantia, to which man has added the sheep and the ox. The roe-deer are especially numerous on the central, and stags on the upper course of the Amoor. In the mountain ranges of the little Khingan and the adjoining plains are many wild boars. Pigs are found more often among the Chinese than among the Russians. The latter rely solely upon the horse as a beast of transport, while the Chinese use the

Shrubs, Grapes, and Wild Boar near the Amoor.

ass and mule in addition. But even in Russia horse-breeding is only carried on on a small scale. In a country so rich in forests, lakes, and marshes, it is not surprising to find a great variety of birds. There are, in fact, 211 species, but they have at present but little significance with respect to practical purposes, with the exception of the tame birds and those which are sought after by the sportsman, as fowl, ducks, geese, black grouse, red grouse, and pheasants; here, too, the Russians and the Chinese differ in taste, the former keeping more fowls, and the latter more ducks and geese. Swans are a rarity. The inhabitants of the country round the Amoor set but little store by the feathered tribes which inhabit their vast forests; but they bestow great care and attention upon the fish of their seas and rivers The lower Amoor is particularly famous for its different kinds of sturgeon, salmon, and carp; in the central Amoor, besides the kinds just mentioned, sterlet, sheat-fish, and various smaller fish are caught; but the waters of the Ussuri are distinguished above all other rivers by the abundance and variety of its fish. If we include its lakes and affluents, we find such a wealth of fish as is seldom to be equalled in any other waters, without reckoning the enormous quantity of salmon which come up yearly from the sea at the spawning season. Travellers relate that the people who wade through the many small channels which connect this river with the neighbouring seas often catch from thirty to forty large fish in a few minutes, using their hands as their only fishing tackle. In fact, fish is the chief article of food eaten by the natives, and it is caught with spears or hooks (without bait), and in rare cases with nets. The Russians were the first to introduce nets and pots. A great quantity of fish is stored up for winter provision; and as salt is dear, they open the fish caught in the summer, dry it in the sun, and store it in their houses. Even the dogs are fed on cakes of dried fish specially prepared for them. *Reptiles* and *amphibia* are scarce, and little attention is bestowed upon them, perhaps because the only snake which is found on the Ussuri, the *trigonocephalus blomhaffii*, is poisonous. The *insects*, on the contrary, are a fearful scourge to man and beast. All the people who go into the forests for the chase, or who get in the hay, and fish the rivers during the summer season, are obliged to protect themselves by nets from the stinging flies in the daytime, and from the gnats at night. It is owing to the attacks of these venomous pests that the beasts of burden are disabled just when there is the greatest abundance of fodder; and it is not an unusual occurrence to find valuable horses or oxen stung to death. The Chinese do not protect themselves by nets, but by wearing a sponge fastened round the head with twisted wire; the sponge is then set on fire, and the smoke keeps off the insects. It is, however, a very imperfect protection, because it only protects the face, and not the neck and hands. Bees are reared by the peasants dwelling on the banks of the central Amoor.

The fauna and flora of the Amoor land are closely connected with those of the coast lands of Primorsk. Coniferæ abound here from the north of Nikolaievsk as far as Imperatorhafen, the larch, fir, and pine being the principal representatives; the marshy forests are filled with mosses, juniper shrubs, raspberries, and wild cherries. In the centre, as far as 45° north latitude, coniferous and non-coniferous trees strive for the mastery; in the south the coniferæ are the exceptions, being found only on the heights, while the lowlands are rich with maple elms, white beech, maple, linden, oak, ash, acacia, vine, a number of orchids and other parasitic plants. The woods often assume the form of an impenetrable thicket filled with the trunks of rotting trees. The forests never extend to the sea coast, but run parallel to the shore, at about four miles distant from the coast line. The inclement wind blowing from the water is the cause of this. Among special forms we may mention the ginseng plant and the sea weed *zostera*. The latter is a source of considerable wealth to the inhabitants of Primorsk; for the ribbon-like grass is so abundant along the coast, that about 1,200,000 cwt. are sent yearly to the European markets, and used for upholstering purposes. Sea grass and trepang (about 260 cwt. yearly) are other articles of export.

Trepang is made of *holothuriæ*, animals belonging to the *Echino dermata*. The Mediterranean and Adriatic seas are frequented by the common holothuria, which is found both in deep water and in shallow places near the coast, and often grows to a length of ten inches. It can endure several hours' exposure by the ebb tide, only taking the precaution of drawing in the feelers round the mouth. The leathery, brownish, or black skin preserves it from being dried up, and the creatures lie about on the sand or between the stones without a sign of life, like unpleasant-looking sausages. Neither the birds who seek their food from the sand, nor men who are busy collecting the fruits of the sea, bestow a second glance upon these animals. If we wish to watch their sluggish movements, we are obliged to observe the specimens covered with water. The end of a feeler is slowly protruded. and the mouth opens to receive, without any apparent choice, everything that is put into it, taking in mud, stones, and fragments of shells indifferently; sometimes, by chance, receiving a mixture of something more digestible. When you have contemplated this process for a sufficient length of time, you may wish to examine the animal more closely, and you take it in your hand. What is the result? It shrivels up with a sudden convulsive motion, and spits out all its own inside! Any one who has once made this experiment, and found himself bespattered with the sticky and clammy contents of a holothuria, will afterwards approach the amazing creature with respectful caution. The *Stichopus* of the Philippines, when exposed to the air, melts away in a few moments into formless slime. Under the name of trepang, holothuriæ, prepared in various ways, are sent to China, and sold for a high price. In the Palau Islands, west of the Carolinas, these creatures are piled up in large iron dishes covered with several layers of leaves *(Caladium esculentum)*, boiled, and then steamed over a very small quantity of fresh water. During the process they shrink to such a degree that a holothuria twelve inches long when first caught contracts to from two to three and a half inches. After this first boiling they are dried in the sun, and then alternately steamed and dried several times. The stichopus, called by the Malays hanginum, *i.e.*, "melting in the wind," has to be boiled before it is taken out of the water, and the trepang composed of this species costs more than eighteenpence a pound, while that made of the common holothuriæ only costs fivepence or sixpence. Neither trepang nor the Indian swallow's nest has any taste of its own; hence they are served up in highly spiced soups, where they look like soft, milky lumps of jelly, and are liked by Europeans for their being so easy of digestion, and by the Chinese for their supposed stimulative properties.

The aspect of the grassy plains of Kamschatka is very similar to that of the park-like scenery of Amoor. The carpet of turf is thick and luxuriant, overshadowed at first by the shrubs which rise above it at intervals; by degrees, however, the grasses and reeds tower above the shrubs, and before their rapid development has ceased it is not unusual to find a flowering shrub six feet high hidden and lost among the surrounding grasses. But the component parts of this grassy landscape are not the same in Kamschatka as in Amoor land. In the former country the mongolian ash is replaced by the birch (*betula Ermani* and *alba*), the shrubs are different, and the creeping plants seem to belong exclusively to the Amoor. The shrubs of Kamschatka are much taller; a spiræa (*spiræa Kamtschatica*), shoots up in the space of only a few weeks, to the height of four to five feet, only to disappear again with the first frosty night. A species of nettle (*urtica*), an umbelliferous plant, and *Heracleum dulce*, or bearsfoot, all rise far above the grasses. Among the noticable fish of Kamschatka we must not forget the red salmon (*Salmo erythræus*), which only deserves its name at the spawning season, when its body is covered with brilliant red scales, and its head is of a dark-green colour. These colours afterwards disappear, and the fish is more soberly arrayed in two shades of blue. The change in its appearance is so striking, that the Kamschadales have endeavoured to find out an explanation; and, according to their idea, the salmon exerts itself so violently in forcing its way up the foaming rivers, that the blood rises to the surface, and colours the skin red. It is certain that, when the red colour disappears, the outer skin becomes much thicker, and looks as if the scales had fallen off.

The Kurile Islands are peculiarly situated as to climate. According to Russian official statements, the climate of this island group, which consists of twenty-two larger, and some smaller islands, is extremely variable in all of them, and differs considerably between island and island. It is on the whole severe, because its exposed situation allows free development to all the winds passing over the ocean. Only the spring is pleasant; but the summer brings with it cold, wet fogs, storms, chilly dews, and now and then days of scorching heat; the winter is long, and very severe. The effects of these extremes on the organic life of the islands is most interesting. The lowlands by the sea are almost entirely destitute of vegetable life; the heights, covered with perpetual snow, afford only a scanty and stunted flora, but in the sheltered valleys we find displayed the whole store of the scanty plant life of the islands. Its principal productions are fresh grass, blackthorn, bulbous plants, parsley, cabbage, and nettleworts. The northern islands have no forests, and produce only alder bushes and stunted pines; the ninth and tenth islands grow willows in addition to the trees just mentioned; the eleventh has no trees of any kind whatever; the thirteenth has plenty of birches, and the southern islands have splendid forests of alder, poplar, birch, mountain-ash, and crooked oak. In many places the soil is suitable

SCENE IN KAMSCHATKA.

for agriculture; potatoes, cabbage, and turnips throve admirably when tried, and the natives enjoyed the harvest, but neglected to secure seed for the next year's crop. The fauna is scanty; mice are found on all the islands, foxes on a few, bears on the southern, and wolves on the two northern islands. The whole wealth of the island group consists in marine animals. Sea lions and seals abound in all the bays, sea otters are frequently captured on the drift ice, and all, together with sea parrots (*Mormon fratercula*), divers, stormy petrels, and geese, form articles of commerce. The rivers are very poor in fish. Horned cattle were first imported in 1755, and multiplied rapidly, as the islanders only used them for milking and dairy purposes, and not for food. Stalls were built on purpose for them, and kept much cleaner than the dwellings of the natives. But now that Russian traders buy the cattle for slaughtering, the number is decreasing year by year.

The climate of Saghalien prevents any rich development of organic life in that place. The nearness of the cold eastern Asia exerts an unfriendly influence, and in Kussinai (48° north latitude) the average yearly temperature does not rise above 34·7° to 35·3° Fahr., an average which is found in Norway only in latitudes beyond the arctic circle. The inclemency of the climate is heightened by the great rainfall and prevalent fogs in summer, and the immense quantity of snow in winter. Among the scanty stores of vegetable and animal life we must name, first, the forests, fish, and animals hunted in the chase. In the north the landscape is covered with tundras, on which is found the dwarf pine (*Pinis cembra pumila*). The woods in the centre and southern parts of the island have forests of fir, larch, and other coniferous trees, but beech, oak, and elm are also found. In the south of the island the trees are divided into zones of vegetation. *Non-coniferous trees* grow to a height of 720 feet above the level of the sea; *coniferæ* are found from 720 to 1,000 feet; above them, up to 1,300 feet, comes the birch, and highest of all, the dwarf pine. The most luxuriant woods are found in the south-west of the island, where the vegetation is so far improved as to be generally considered to belong to the monsoon district. The natives live by fishing and hunting. The sable, otter, fox, and bear skins are bought by Russian, Japanese, and American traders, while fish is the staple article of food for home consumption. Vegetables, that is, cabbage, potatoes, and cucumbers, are grown freely; but corn, though having been cultivated in some places with success, is still imported from abroad. The Chinese import rice from Japan, and the Russians get their corn from Russia, so that the latter article is forced to make a voyage round the world.

Steppes.

From Ekaterinburg to Omsk extends the Ischim steppe, from Omsk to Irtisch, from Irtisch to Altai, steppes, and nothing but steppes, make up the scenery of south-western Siberia. Ekaterinburg is chiefly noted for its fish market. A long train of sledges is loaded with valuable cargoes of fish bedded in snow. Sturgeon, sterlet, perch, eels, and other fish, all in a frozen condition, are laid upon the sledges. Only pike and perch, the latter twenty inches long, are brought fresh from the Isset, all the others are brought frozen on sledges from Tobolsk, a distance of more than 348 miles. Some travellers report that in Lent fivepence a pound for the fish (*Coregonus Nelma*) and threepence for pike was thought an extremely high price.

The Ischim steppe, from Ekaterinburg to Omsk, was traversed during the latter winter months, but presented no field for special observations. The scenery is at first heath-like with stunted pine woods; these are succeeded by birches, small coppices alternating with marshy places and lakes; the true steppe does not begin before the right bank of the Irtisch. Beyond Omsk the typical steppe surrounds the traveller on every side; the eye sees no horizon but the sky-line, no undulation of the soil, nothing but a few meagre trees growing near the villages, and twisted and stripped of their leaves by the incessant winds. The soil is soft, yielding sand, without any stone or vegetable growth, and covered with locusts. The steppe has by no means this character of *treelessness* everywhere; on the contrary, it is so much varied, that it is difficult to describe it in a few words. We generally picture it to ourselves as a boundless monotonous extent of grassy plain; but grass is only found upon it in isolated patches, and does not grow like a smooth carpet of turf, but in separate bunches, like the buffalo grass of the prairies, only somewhat longer. In some places the steppes are covered with copses of spiræa, whose branches, before the leaves appear, relieve the predominant yellow-brown tints with a darker shade. Gooseberry bushes, and stunted dwarf birch not more than five feet high, are seen here and there; but wherever the track lies along the banks of the Irtisch, we find a fine growth of willows, poplars, oaks, birches, and especially firs. The numerous islands are generally overgrown with willow bushes and reeds. Along the river-side long chains of sandhills recall the dunes of Holland, and have a vegetation similar to sandwort and other grasses. These peculiarities are sufficient to mark the great difference between the steppe and the prairies, which are, at least to a very great extent, characterised by a total absence of trees. But the special distinction of the steppes is the number of pools and tarns of all sizes. These sheets of water are generally isolated, without tributary or outlet; and, stranger still, the water is sometimes fresh, sometimes salt or brackish; so that they are found in certain places surrounded by dunes of sand, and in others by incrustations of salt, which impart to the ground the appearance of a plain covered with snow. The most singular and characteristic plants are found near these lakes. A beautiful blue-flowering anemone was seen there by a traveller on the 28th of April, a yellow ranunculus (*Draba*), and the inevitable varieties of crowfoot and leek, which are among the first to obey the call of spring. The fauna is more richly developed, and the waters are covered with numbers of ducks and swans. Flights of swans, numbering more than twenty birds, are often seen circling overhead, as if to tempt the sportsman. Gulls of various kinds abound, and the graceful movements of the snowy birds, as they wheel above the sandy steppes, far from the water-side, in search of worms and insects, lend a charm of life to the desolate scene. Flights of smaller birds were as yet seldom seen; in April the countless holes used by the shore swallows for their nests were still empty. On the 26th of April appeared the first white-winged lark (*Alauda Sibirica*), in wide circling flight, while the field lark had already taken up her quarters, and defied the storms of snow and hail with her sweet brave song. In and near the villages, magpies, daws, rooks, and crows were met with, together with starlings and sparrows. But the starlings' nests, on their high perches, had not been preserved, and the magpies and crows had to manage as best they could to build on stunted shrub-like birches. Besides these village birds, falcons, hawks, and kites abound, the latter being especially bold and audacious. The beautiful red-footed falcon, the most charming of his tribe, perched by preference along the telegraph wires; indeed, these novelties of civilisation seem to have a peculiar attraction for every kind of bird of prey, the posts and wires being covered with the feathered robbers. Falcons and different kinds of eagles were often seen upon the posts, but the true birds of the steppes seldom put in an appearance. Here and there dwarf bustards were seen circling in unwieldy flight, and sometimes great bustards were noticed. The white ptarmigan (*Lagopus albus*) were found in great numbers. On the 27th of April came the first plovers (*Vanellus gregarius*), and true to their name (*gregarius*), remained near the herds of cattle. Wild quadrupeds were not seen, with the exception of the white hare (*Lepus variabilis*), which was wearing its summer suit of grey fur. Marmot, and long-eared hedgehog (mentioned by Pallas) had not yet awoke from their winter sleep, and the larger quadrupeds, including the longed-for saiga antelope, according to the guides, are never seen on the shores of the Irtisch. Other travellers, Pallas among their number, assert that they abound in this part of the country, swim across the Irtisch, and wander to great distances, not, however, reaching as far as the Ob, though they have been seen at Baraba; and Gmelin, in his travels along the shores of the Irtisch, mentions the numbers of wild boars, "as large as I have seen them anywhere," and adds, "they eat nothing but grass and roots; in the winter they root up a kind of grass from under the snow, and feed on that." In spite of this poverty, the steppes presented an animated appearance, to which the presence of herds of cattle, belonging, for the most part, to the Kirghis, greatly contributed.

By degrees the birds of passage returned from their southern quarters, the dormant creatures woke from their winter sleep, and the flowers began to spread themselves over the plain. The peonies were especially magnificent, and their blossoms of fiery red shone from the distant slopes of Alatan, outvying even the tulips in brightness and splendour of colour. The tulips, indeed, were a disappointment. "We had seen tulips in flower at Sergipol," say our travellers, "but nothing resembling these boundless stretches aflame with yellow, dark-red, white, and striped tulips such as we had pictured in our imagination. The tulip fields of the steppes fall as much below our expectation as forming the beauty of the landscape, as does the tulip itself when considered as a solitary flower. It is, indeed, by no means an imposing plant; the stem is from two to six inches long, and the flowers never longer than one inch. The colour is invariably yellow—at least, as far as our experience extends. Next to the peony, the sword-lily lends its hues of blue, violet, and yellow. At the time of our journey across the steppe, wild leek and the bulb of a small white flower, a kind of snowdrop (*Gagea pusilla*), called by the Russians of that neighbourhood *kandyk*, are eaten and much relished by the natives. Numerous representatives of umbelliferous plants, probably ancestors of many found in our own gardens, appeared luxuriant in green succulent leaves, which were dried up only too soon by the heat of the summer. The spiræas were the first to answer to the breath of spring, and in moist places we saw ranunculus and the white flower named above."

Before saying farewell to the steppes, we should mention that the soil is extremely fertile, consisting of that famous black earth, rich in mineral substances, which is found also stretching from the Pruth to the Ural, so that it seems as if the earth which has lain for seven or nine months under a thick covering of snow only waits for the agriculturist to become one of the most fruitful regions of the globe. Waldburg is inclined to believe that the whole steppe of Kulan was once the bottom of the sea. The rounded pebbles, scattered or piled up in heaps, seem to support his theory, as they are of foreign origin. They seem to have come with ice of the Kara-Irtisch, sunk into the sea, and remained on the bed as the waters sank gradually down.

But the steppe presents a different aspect to the traveller who chooses another season for his visit. Humboldt describes the scenery near the Irtisch as being all ablaze with reds and crimsons, owing to the abundance of the narrow-leaved *Epilobium angustifolium*, the fiery red *Lychnis chalcedonica*, and the tall blue larkspur (*Delphinium elatum*).

Lastly, we must mention the most important animals of the steppes. The carnivora are represented by the tiger, wolf, fox-dog (*Canis corsac*), and leopard. The corsac is the only one peculiar to the steppes: tigers wander over all the northern continent as far as lat. 53°. Wolves of various kinds are found not only in Europe, but in the north, east, and centre of Asia, and the *Leopardus irbis*, a rare species of leopard, is also met with near Lake Baikal. The fox of the steppe (*Canis corsac*) is an animal much resembling our fox, and hunted for its soft, warm, and beautiful winter fur. It is pursued by every possible method: smoked out of its lair, chased by dogs, or caught in snares and traps. The Kirghis often capture it with an instrument resembling a double cork-screw fastened to a pole. They pierce the unfortunate animal with this cruel instrument of torture, and drag it from its hole. The poor creature, when so captured, is said to tremble from head to foot, and offer no resistance to its tormentors. Let us turn to a less barbarous description of a hunting scene related by Finsch:—

The news that the governor was going to hunt in the mountains of Arkat ran like wild fire through the steppe; and from far and near the Kirghi chiefs hastened to shew their respect to their favourite ruler. They came, accompanied by a large retinue, including popular minstrels, famous marksmen, falconers, celebrated runners, and the native dogs. The latter are grey-hounds, something like the shaggy Scotch deerhound, but having long hair only on the ears, the lower part of the leg, and the tail. Judging by the few specimens I saw, they are small ugly creatures, but said to be unsurpassed in the antelope hunt. We were not, however, fortunate enough to see any proofs of their skill, or of that of the birds, of which one was present. The Kirghis have no meaner bird to hunt for them than the king of birds himself, the great crag eagle (*Aquila fulva*). The majestic bird sits on the wrist of a falconer, which is well protected by an immense glove of bearskin; and as no arm could long support the weight of a bird weighing twelve pounds, the arm is supported by a prop fastened to the knee or the saddle bow. The eagle's head is covered by a hood of leather; his legs short chained. He glances wildly round when the hood is removed, and flutters with his wings, as if longing to take flight The eagles are especially trained to bring down corsacs and wolves. Atkinson relates that he saw an eagle fetch down a stag in the steppes, a hardly credible story, as a stag is scarcely to be found in the steppes. When let loose against a wolf, two birds are generally sent out together, and they attack the wolf on the back and neck with outspread claws, but they are not always successful. The price of a trained eagle is very high, and therefore this noble sport can only be carried on by chiefs. The Kirghis told us that no bird could be properly trained unless it was taken from the nest when quite young.

A real animal of the steppe is the ancestor, as it is believed, of our modern horse (*Equus hemionus*). The Kirghis call it *Kulan;* the Mongols, *Dschiggetai;* the Tungus, *Dschan;* the Thibetians, *Kiang*. It is generally met with near lakes and rivers; but the changeful climate of its home often drives it out into dry, waterless tracts and bare mountain slopes; for it is an epicure, and, preferring wormwood to any other food, it has generally to put up with scanty fare. The incredible swiftness of the animal, and the value it brings to the huntsman, incite to its chase. The flesh is highly esteemed by the Kirghis and Tungus, and parts of the hide are sought for by the natives of Bokhara for the manufacture of morocco leather; but nevertheless, where not interfered with by human settlements, it is found in large numbers on the boundaries of Europe, in the district of Akmolinsk.

The *Ovis argali*, a large sheep, nearly six feet long, and standing five feet high, is also found on the steppes, though its favourite dwelling place is sparely wooded mountain chains abounding in barren tracts of rock, and rising from two to three thousand feet above the level of the sea. It is extremely agile, and so swift that a laden horse cannot overtake it; so that when it falls in the chase it does so more from the consequences of its curiosity than from the skill of its pursuers. Steller tells us that a kindred species, the large-horned sheep, found on the mountains of Kamschatka, is diverted by a scare-crow made of rags, while the hunters approach stealthily within gun range. Przewalski relates a similar story of the argali, and he proved the truth of the assertion by hanging out a shirt on a pole, and so fixing the attention of a flock of wild sheep for a quarter of an hour.

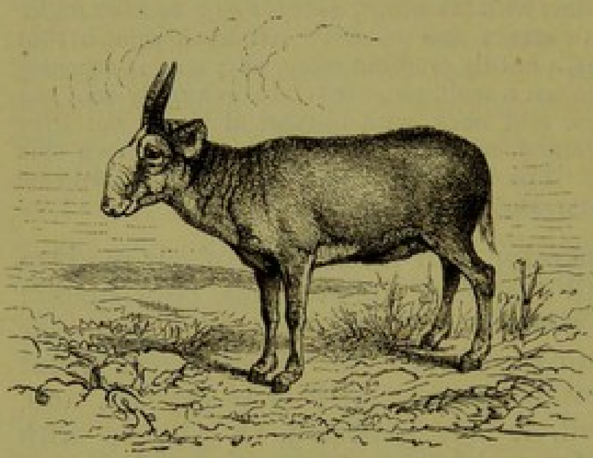
Other animals found on the steppes are the wild *boars* of the river banks, the saiga antelope, marmot (*Spermophilus citillus*), and the long-eared hedge-hog, cousin of our own hedgehog, the *Erinaceous auritis*.

A charming little animal is the Russian jerboa (*Sircetus jaculus*), about the size of a squirrel, and distinguished by a magnificent long tail, and by hind-legs four times the length of the fore-legs. When quietly feeding, it moves along on all-fours; but when alarmed, it springs like the kangaroo, using the hind-legs only, and so swiftly that the best horse cannot overtake it. Its flesh is greatly liked by the inhabitants of the steppes.

A variety of the Alpine marmot (*Arctomys bobac*) is found in a tract of land reaching from south Poland and Gallicia across southern Russia and Siberia, as far as the Amoor and Cashmere. Like the prairie dogs of North America, they throw up heaps of earth into little hillocks when they make their holes. It is a strange sight to watch an encampment of these animals, when it is possible to approach near enough to their dwellings. Countless lines of hillocks stand side by side, and on the top of every one a little creature of about thirteen inches, like a squirrel, sits upright, clothed in fur of rusty yellow turning to greyish white on the front of the neck.

We have already spoken of the principal birds, and there is not much to say of reptiles or poisonous snakes.

The travellers went for a delightful excursion from the steppes to the beautiful lake of Dschasil-Kul, in Ala-Tau. A splendid vegetation, both as regards trees and flowers, rejoiced the heart of the botanist, and filled even the uninitiated with a consciousness of singular beauty and variety. In the valley were found tall, well-grown poplars, aspens, and willows; on the heights, *coniferæ*, especially the *Pinus schrenkeana*. The wild apple trees were in full bloom, covered with a glory of rose and pale-pink blossom, affording a proof that the milder sky of a lower latitude was shining overhead (lat. 46° N.). The fruit of the wild apple is small, but pleasant tasted, with an acid-sweet flavour, much liked by the Kirghis. Among the apple trees, whose fruit ripens in July, grow a number of flowering shrubs, mingling their rich odours with the aromatic scent of the pine wood, until the air was laden with fragrance. From this point the steppes are broken by reed forests, in which succulent herbs and coppices of tamarisk abound. The reeds near the Lentek are very thick and tall. Among their green stems one catches gleams of the brilliant golden yellow-hammer (*Emberiza luteola*), and the deep red of the cherry finch (*Carpodacus erythrinus*), which flashes like fiery sparks to and fro. The graceful crane was as great a novelty to the eye as was the welcome song of the nightingale (*Lusciola philomela*) to the ear, as it sounded from the reedy shores of the river. There was no lack of aquatic birds near every lake.



SAIGA, OR ANTELOPE OF THE STEPPES.
52 inches long: the tail (4½ inches) included.

Our travellers left the steppes towards the end of April, and ascended the picturesque promontory of the Chinese Upper Altai. Pleasant meadow valleys, shaded by tall birch and trembling poplar groves, led them on to the mountains. There was no after-growth down the Chinese part of the southern slopes of the Altai as far as Lake Marka. Nothing but ancient larches were seen to the limit of the tree line, about five thousand feet above the level of the sea. The pine (*Pinus Sibirica*) does not grow so high, and is more often found near brooks and in the valleys. There is no young undergrowth to be seen. The reason for this may be sought in the reckless fires which are kindled yearly without any control or supervision. The solitary groups of trees contrast strangely with the distant snow fields of the bare crests, and still more strangely with the merry notes of the field lark, and the luxuriant meadows covered with violet and pale-yellow pansies (*Viola tricolor*, *vulgaris*, and *altaica*), yellow primulas, and a fine blue gentian. Even the moist pasture grounds of the mountains are carpeted with flowers. The scenery recalls that of the green Alpine meadows, but here there is no sign of human life, with the exception of a few wandering shepherds, now and then a horse grazing, or a log hut like those of the Swiss mountains. The log huts of Altai, however, afford shelter to no merry Swiss shepherd lad, and contain nothing but the bones of dead Kirghis, and are, in fact, graves. The way to Lake Marka lay through forests. It is utterly impossible to penetrate into the interior of such a forest: the way is stopped on the heights by bramble and thicket, and in the cauldron-like valley by quaking bogs and fens. Masses of enormous formless fragments of rock and stone are piled together in chaotic confusion, overgrown with lichen and parasitic plants, which hide the treacherous rifts and holes between the stones; fresh undergrowth shoots up on every side, and contributes greatly to the difficulties of the passage. But in the lowlands every solitary tree, every large bush, stands upon a separate island created by itself, and surrounded by stagnant, slimy water rising to the surface or hiding under ground. Tall, noble trees, torn up by the constant resistless winds of winter, lie stretched at full length upon the ground, some withered, but still resisting the spread of the growing corruption; others totally decayed, rotten, and eaten away; overgrown and covered by young stems of its own kind, which have struck root near, or even within the body of the fallen giant. Others, again, have left no trace except the deep indentation made by their fall in the soft earth; they themselves have long since rotted away. Trunks of equal height rise side by side, robbed of their leafy crown, and marked for destruction, or are seen standing with shattered crest and branches broken by the storm. Dense thickets alternate with bare clearings, tall forest trees with shrub-like undergrowth, grey, hoary giants isolated in a tangle of bush and brushwood. The whole scene gives the impression of a wilderness, and strikes the spectator with amazement rather than with admiration. The last sentence is but the subjective verdict of a single traveller; others have found the aspect of these primeval forests far more sublime than that of our own well-kept and neatly trimmed woods. The curious peculiarity of these woods—namely, the total absence of the dwarf pine (*Pinus pumilis*)—has often attracted notice; and also the fact that the tree growth of the higher mountain regions is by no means of a dwarfed and stunted character, but consists of larches of more than sixty-six feet in height; bent out of the perpendicular, it is true, or robbed of their branches by the wind. In the mountains of Korgon and Koksu, at the height of 5,000 feet above the level of the sea, perfectly healthy specimens of the *Pinus cembra* were found; at the height of 5,850 feet, the stems measured fourteen feet in circumference; the highest found were 6,720 feet above the sea. The *Pinus cembra* is here the tallest conifer; but it is much rarer than the larch (*Larix Sibirica*), which grows to the height of 5,550 feet above the sea. The pine (*Picea vulgaris*) is found rather lower (4,020 feet), and the Siberian fir (*Abies Sibirica*) grows above the Scotch fir, and is not met with below 2,560 feet above the sea.

Central Asia.

The traveller who journeys from the civilized countries of Europe to the "flowery" or "celestial" empire of China, finds in the steppes of Irtisch a foretaste of the barren desolation which he will have to encounter in Central Asia. This name, which answers to no definite geographical idea, is meant to represent the lands east of the Caspian Sea to the limits of the Chino-Japanese vegetable kingdom, so far as the latter belongs to the Siberian sub-region of the animal kingdom; it is, as a glance at the map shews, the eastern part of the region of the steppes. This region, extending from the mouth of the Danube, on the Black Sea, to the tributaries of the Amoor, from the central Volga to the coast of the Arabian Sea in Belooschistan, and the principal Indian summit of the Himalayas, divides not only the western culture of Europe from the eastern civilization of China and India, explaining by its very presence the isolation of each system of culture, their separation in history, and their absence of reciprocal influence, and it led the wandering tribes to create a settlement and formation of a civil community of government and order only in such places where agriculture was made possible by the presence of running water.

A rainless, hot summer characterises the whole district; and as the climate is continental, owing to the great distance from the coast, the contrast between the seasons is very strongly marked. The time of vegetation in the spring is shortened by the length and rigour of the winter. The time allowed for the development of plants is restricted, as in the far north, to a period of three months at the most. The short spring affords almost the only chance vouchsafed to the vegetable world for growth and development, because the snowstorms of winter follow almost immediately on the scorching droughts of summer. Only plants specially adapted for such conditions could resist the sudden changes, such, for instance, as bulbous formations, or plants protected by hairs or bristles, which are able to prolong the period of development; but as the real obstacle to other forms is the absence of water, artificial culture can supply the deficiency by the rivers and mountains which supply moisture even in summer. The territory of Central Asia exhibits many peculiarities with reference to its organic life. In the south rise lofty mountain peaks, more than 20,000 feet in height, while its north-western side is bounded by the Aral Caspian depression, which lies below the level of the sea, and has an extent of 208,000 square miles. What a rich variety of vegetation one would naturally expect from this vast region; and yet, as a matter of fact, botanically and also zoologically speaking, Central Asia is the most barren and unprofitable region on the surface of the earth. Deserts and steppes abound, but there is very little soil capable of cultivation. Perhaps about a twentieth part of the whole highland of Turania may be more or less fertile, but the total productivity of the steppes in the north, from the Aral Sea, with those of Syrdarja, Ust-Urt, and the oasis of Khiva, an area of about 192,000 square miles, only equals that of from 1,760 to 1,920 square miles in the south of Russia, and from 400 to 480 square miles in India. The deserts between Khiva, Bokhara, Merv, Atrak, and the southern point of the Caspian Sea are not included in the calculation, because they are almost absolutely barren. Even mountain ranges whose crests rise far above the line of perpetual snow contain slopes which are for the most part deserts, and the plateau of Alai, 8,500 feet above the level of the sea, between chains of snow-clad hills, is an unbroken waste. The drought of the climate is the cause of this wide-spread barrenness. In Alexandrowsk, on the coast of the Caspian Sea, scarcely two inches of rain falls throughout the year, and in the interior of the country the rainfall is even smaller. The summer temperature rises to 113° Fahr., while in winter the cold is so intense that the Caspian Sea is deeply fringed with ice. More disastrous still is the extreme irregularity of the rainfall; for it often happens that a field sown in spring receives no rain whatever throughout the summer, and yields no crop.

If we turn to examine the eastern side of the district, we find ourselves in the desert of Gobi, an area estimated at 640,000 square miles. The name Gobi, or *Schamo*, means sandy sea, and the ground consists generally of coarse red gravel and small pebbles, sometimes containing different kinds of stones, especially agate. Here and there are found large tracts of yellow drift-sand. Such a soil is, of course, not calculated to produce a luxuriant vegetation; and consequently the Gobi is poor even in grass. It is true that it is rare to meet with absolutely bare places along the road to Kalgan, but the grass seldom grows higher than twelve inches, and barely covers the reddish-yellow soil. Only where the gravel is replaced by loam or clay, and where the mountain valleys have allowed the summer moisture to remain long enough in the earth, bushes of *Lasiagrostis splendens,* a shrub resembling broom, grows to the height of from five to six feet, and extends its leaves and stems as stiff as wire. Flowers sometimes are met with; for instance, leek, wormwood, and a few composites. There are no trees and shrubs of any kind, since, in addition to the hindrances to vegetation which have been already mentioned, the violent gusts of wind in spring and autumn, which sweep across the ground day and night, with such irresistible force that they tear up even the low-growing wormwood by the roots, and rolling it together in large masses, drive them across the desert, and destroy many a vegetable life in its first beginnings.

Thus the desert of Gobi gives to the traveller an impression of utter monotony and desolation. For weeks together the eye falls upon nothing but a repetition of the same objects; boundless plains, yellowed over in winter by the prematurely scorched grass of the preceding year, broken by jagged ridges of rock or rugged chains of hills, on the crest of which sometimes appears the form of the swift-footed antelope of the desert (*Antilope gutturosa*). With measured tread the heavily laden camels advance; they go for ten, or even a hundred miles, but the character of the steppes never changes, but remains inhospitable and unfriendly. The sun goes down, the black night-shadows descend over the desert, the cloudless sky glows with myriad stars. An hour passes away, and men and beasts are all asleep, and the death-like silence of the desert closes round, as if no living being breathed within its limits.

We quote from the description given by Przewalski, lieutenant-colonel in the Russian army: "Day after day passed without any relief to the monotony of the journey. We had chosen the central caravan track from Kiakhta to Pekin, setting out on our march generally towards midday, and journeying till midnight, accomplishing generally from twenty-five to thirty miles a day. In the daytime I used to walk in advance of the caravan, and shoot any birds which happened to come within my range. Among these the crows, and in summer also the hawks, were looked upon, from their shameless intrusiveness, as our declared enemies. Again and again they carried off not only our store of meat, but even the prepared skins. The crows, which are so wary and cautious among ourselves, are so daring here, that they enter the Mongols' tents to steal their store of provisions. And not satisfied with this, they perch on the necks of the camels when the latter are turned out to pasture, and peck at their necks and humps. The stupid, frightened animal utters cries of pain, and spits at its antagonist; but the crows only rise up to settle down again, and often inflict serious wounds with their sharp beaks. Such is the power of hunger, and how can it be otherwise, since the Mongol looks upon it as a sin to kill these birds? Of other creatures we frequently saw the bird of the desert, *Syrrhaptes paradoxus*, whose exclusive home is the steppes, where it feeds on seeds, principally on those of the *Agriophyllum gobicum*, a small, prickly, salt plant, akin to the sea purslain. It winters in the desert;

KIRGHIS, WITH DROMEDARIES.

but when the heavy falls of snow prevent it from finding its food, it migrates to the northern plains of China, but only until the weather is favourable enough to allow of its return to its native desert. In the summer it wings its flight to Trans-Baikal for the breeding season. After a few solitary out-runners had been despatched by this strange bird, large flocks came over to Europe in the year 1863, and stayed till October on the coasts of England, Scotland, and Holland, penetrating to France as far as the Pyrenees. A few pairs remained to breed in Europe. Besides the *Syrrhaptes paradoxus*, the Gobi is the home of several kinds of lark, one of which, the Mongolian lark, or *Melanocorypha mongolica*, in spite of the low temperature, which often falls to 34° below zero, and even lower than that in Urga, bears the hard winter of the desert hidden in the bushes of the Dyrisu, and feeding on the seeds. May we not learn from this fact, that it is not the cold, but the want of food, which drives many birds southward in the winter? The characteristic mammals of the desert are very few, the principal being the antelope and the whistling hare (*Lagomys ogotana*). The poor ogotana, "the short-tailed one," as the Mongols have it, has numberless enemies: foxes, wolves, buzzards, hawks, and falcons destroy it in large numbers every day. The buzzards live upon them so exclusively, that the period of their stay in the desert is terminated by the number of these rodents.

In spite of the desolation and barrenness of the Gobi, the way was enlivened by the caravans of the tea-merchants, who, according to the reports of Russian wholesale dealers, transport yearly 200,000 chests of tea, weighing eighty pounds each, from Kalgan, by means of camels. The Bactrian camel is the only one possessed by the Mongols; his kindred type, the one-humped dromedary, so common in the Turkish desert, is unknown here. The boundless expanse of the desert is the real home of the camel, where it breathes in freedom, and feels perfectly contented as the Mongol, its master. Both have an absolute horror of a settled life; the camel pines for its liberty to such a degree that it wastes away when kept in confinement, even though it is provided with the best of food and the greatest care. It is a model of patience and endurance in the desert, but nowhere else. Przewalski's camels died of hunger on the richest Alpine pastures, because they were deprived of the food to which they were accustomed in the desert. Salt is a necessity of their existence, and they shewed a decided preference for the white saline efflorescence, the so-called *gubschir*, which is found in great abundance in all the tracts where the soil contains salt, and even among the patches overgrown with grass; pure salt, however, they liked less. The ordinary load for a camel is about 486 lb., and the average speed across the level plain from two and a quarter to three miles an hour.

Przewalski's route lay through Pekin, past the southern limits of the Gobi, to Lake Kuku-Nor, as far as the boundaries of Thibet (lat. 40° north, 116° east, long. Greenwich, to 35° lat. and 94° long.), and back again by a somewhat different road, along paths scarcely trodden before by any European traveller; and it will be advisable to note the chief points of botanical and zoological interest observed by him during this long journey of nearly 6,900 miles. On his way from Kalgan to the Yellow River, by the broad south-eastern slopes of the Schara-chada (yellow mountains), he found many plants which are well known in Europe; among them were the juniper, a wild rose (*Rosa pimpinellifolia*), hazel nut bushes, wild plums, spiræa, barberries, currants, medlars, woodbine, and other plants akin to our own flora. Among the bushes he noticed, for the first time in Mongolia, a considerable number of insects. Parallel with the Schara-chada runs the mountain chain of the Suma-chada. These rocky heights are planted with elm, alder, and maple. It is remarkable that not only here, but in all other mountainous regions of Mongolia, without exception, shrubs and trees grow exclusively on the northern slopes of the mountains and ravines. One of the most characteristic animals of Central Asia, the mountain sheep (*Ovis argali*), is found in the mountains of the Suma-chada. It is a giant among sheep, and grows to the height of a hind. Besides these sheep, wolves, hares, and at some little distance even chamois (*Antilope caudata*) were found, while birds are represented by partridges, wheat-ears, yellow-hammers, and larks.

After a long pilgrimage through desolate, treeless steppes, the traveller found the shelter of pleasant groves by the side of the Yellow River, where it winds through the wide plains of Ordos, among the wild alpine scenery of the granite mountain ranges of Muniulla. On the heights of this mountain range there are no forests, but only solitary specimens of the same plants which are found on the Suma-chada mountains. The higher one climbs, the denser is the growth of bush and thicket, until trees are seen here and there, generally firs and a low elm. The forests do not begin until 5,510 feet above the level of the sea, where they are generally found in the northern ravines. Among the trees, many old acquaintances are recognized here, trembling poplars, silver birch, wild cherry, juniper, the "tree of life" (*Thuja orientalis*), and raspberry snowball, and even those varieties which are not found in Europe, as certain willows, and a black birch (*Betula davurica*) are so much like our own species, that the traveller is often inclined to forget how far he is from home, especially as the fauna is of the same European character. Vultures, white finches mountain pigeons, pipers, finches, yellowhammers, nutpeckers, hedge sparrows, woodpeckers, goatsuckers, lapwing, hoopoos, and peewit abound, and only the cry of the ringed pheasant (*Phasianus torquatus*) reminds him that the wood through which he is wandering lies in the centre of Asia. The Mongols themselves have noticed that this mountain range possesses quite a peculiar flora and fauna; and as the southern side is more thickly wooded than the northern, they have invented an explanation as follows: a great saint carried away a mountain from the north, to display his power, but in setting it down he happened to turn its northern side towards the south.

The sandy waste of Kusuptscha deserves especial attention. This desert is about a hundred and ninety miles long, and its width varies between ten and fifty miles. The fine yellow sand rises in hillocks of 40 feet, or in some cases 155 feet high, which stand near to each other; it has no vegetation, and only one living inhabitant, the brownish yellow lizard (*Phrynocephalus*). Round the outskirts is a fringe of small oases, where a sweet clover (*Hedysarum*) grows to the height of about nine feet, and, covered in August with fine pink blossoms, is the chief plant. There is also a flower, perhaps found nowhere else, the milkwort (*Pugionuni cornutum*). The most singular thing is that the formation of these sandhills is due to plants. Clouds of dust and sand driven by the wind across the desert plains are caught and entangled by the low shrubs; the sand settles down, and forms a low ridge, on which other shrubs are blown, and take root. The showers of rain wash away the slowly built ridge into separate mounds, that look as if thrown up by the spade.

The southern part of the high plateau of the Gobi, to the west of the central course of the Hoangho, is a wild, barren waste, called by the Mongols who inhabit it, Alaschan. The tribes which frequent it are called Olutes. Like the plain of Ordos, Alaschan was probably the bed of some vanished inland sea or large lake; the level nature of the ground, the hard salt-clay covered with drift-sand, and the number of small salt-water lakes found within its depressions, all point to such an origin. Sometimes the stretches of sand are so wide that the Mongols speak of them as "the heavens" (*tyngeri*). Not a drop of water is found within them, and no voice of bird or beast breaks the oppressive death-like silence which weighs down the spirits of the traveller in these gloomy regions. There are no oases, and the few patches of vegetation are miserably poor, consisting of a few stunted shrubs and a few dozen specimens of herbaceous plants. The saxaul (*Haloxylon ammodendron*), a tree of twelve or fifteen feet high, with a circumference of six inches only, is some-

GERMAN BEECH FOREST AND ROYAL STAG.

times found standing alone; and its leafless branches, looking like green bristles, form the principal food of the camel, while its thin wood is excellent for fuel. The sulchyr we have mentioned before. This plant may be termed, without any exaggeration, the blessing of the desert; it grows about twenty-four inches high, blossoms in August, and bears toward the end of September a pleasant, nourishing seed or fruit. In rainy seasons it bears well; but in dry years it fails, and brings famine down upon the Mongols. The seeds are roasted first over a slow fire, then trodden underfoot to free them from their shell, ground into flour, which, steeped in tea, makes a palatable dish. But this useful plant, like all the rest, lends little beauty to the scene; it has no look of life or energy: everything bears the impress of decay; the plants seem to grow with reluctance, and find no pleasure in living; and, indeed, the scanty nourishment they receive from the soil only just suffices to preserve them from decay. The fauna is scarcely richer than the flora. Besides the black-tailed antelope (*Antilope subgutturosa*), wolf, fox, and hare, a lizard and two species of martens (*Meriones*) are found now and then in the saxaul bushes. One species of these little rodents lives entirely among these bushes, and undermines the earth to such a degree that it is impossible to ride across it. All day long, when the road lies through such a locality, the monotonous squeak of these animals is heard, and is as wearisome as everything else in the Alaschan. The most singular of the birds is the *Podoces Henderson*, or "feathered runner," a true child of the desert. It runs with extreme swiftness, hence its name, and disappears with the antelope, as soon as the nature of the desert scenery improves and becomes more hospitable, so that these two animals are unpleasant harbingers for the traveller. The very sight of the bird is enough to shew that the unmitigated desolation of the desert is at hand. Prairie fowl, larks, sparrows, and in the summer time that charming visitor to our zoological gardens, the maiden crane (*Grus virgo*), are also found. As there are no morasses here, the cranes come to the wells to drink, and become very tame and fearless, since they are never hunted.

The Alaschan mountains afford a welcome contrast to the desert. The chain is from 125 to 158 miles long, and very narrow, being not more than fifteen miles wide in the centre. It rises sheer from the plain, having a wild alpine character; the eastern chain especially consists of giant rocks rising perpendicularly to the height of 720 or 820 feet, and of deep precipitous ravines. The highest peak has an absolute height of 11,900 feet, and although not reaching to the snow line, the heights are generally covered with snow by the end of September. The base of the mountains is covered only with grass and curious little shrubs, and not until the western slope has been climbed to the height of nearly 7,770 feet does the traveller enter the forests of spiræa, intermixed with fir and willow. On the eastern slopes, woods begin probably in a lower absolute height, and are composed of a small trembling poplar, and more rarely silver birch, pines, and fine junipers. The thick undergrowth is made up of spiræa and hazel, above which grows a prickly acacia (*Caragana jubata*). The higher part of the mountain is covered with alpine meadows, which rise in strange and beautiful contrast to the expanse of desert which surrounds the foot of the mountain. Here is the classic home of an interesting fauna, comprising the eared pheasant (*Crossoptilon auritum*), the musk, stag, and ibex.

The birds of passage of Siberia seek their winter quarters south of the Gobi. Przewalski observed in all about twenty-six kinds. Some of these, however, came in small flocks, and even singly. Geese and cranes passed by in large numbers, flying high, and seldom alighting to rest. Their course lay probably through China proper, toward the north, along the mountain-side, and they are only driven by necessity to the desert, where they have to contend with cold and hunger. The winged wanderers are driven from the warm plains of China into the waterless waste, beyond which lies the blessed north. For Siberia, forbidding as the name sounds to us, is, in comparison with the deserts of Mongolia, a perfect Eden; the Siberian spring is really spring-like, and not the miserable season it appears in the Mongolian deserts. Neither March nor April brings to the wanderer in the desert the slightest token that the world had awoke from its winter sleep. The yellowish grey of the sand glares inhospitably upon him, and very rarely does a lark break the silence. The end of April brings with it great heat, the thermometer rising to 86° Fahr. in the shade; but no rain fell, and the dry heat is as disastrous to vegetation as the previous cold.

RHUBARB PLANT (*Rheum palmatum*), WITH FLOWER AND FRUIT.

Only twenty-five miles to the south of Alaschan rises the Gansu mountain range, and both fauna and flora shew a marked and sudden change. Lofty peaks rising above the line of perpetual snow, fertile soil, moist climate, and consequently abundance of water, contribute to the change. Rich grass covers the plains and valleys, noble forests overshadow the steep slopes of the mountains. As usual, the woods are principally found on the northern slopes, as if they sought for shelter from the scorching sun, although the latter does not often break through the clouds during the summer. The very first step reveals to the traveller new forms of plants, together with many familiar friends of his native land. Among the former is a birch (*betula Bojapattra ?*), hardly distinguishable from its neighbour, our own birch, but with a red bark. These two are the principal trees of the lower forest region. Higher up, trembling poplars and mountain ashes like our own, and peculiar forms of firs, pines, poplars, willows, and an arborescent juniper, extending to the region of alpine plants, that is, to a height of about 13,000 feet. The Tungus and Mongols look upon this juniper as sacred, and use its branches for incense during their devotions. In the higher ravines, and on the brink of the torrents, are found among many plants which are, or appear to be, familiar many fresh forms, especially the rhubarb plant (*Rheum palmatum*), called by the Mongols *Scharamoto*, or yellow wood, and by the Tungus, *Dschumtsa.* We shew in the preceding illustration the fruit and blossom of this useful plant. As to its size, the largest leaf ever found was twenty-five inches long, and thirty-nine inches wide, the flower stem measuring from six to about thirteen feet high. The stem is green near the root, reddish at the top, and covered with very small red lines. The roots are gathered by the Chinese and Tungus in September and October. Political troubles have, however, latterly greatly impeded this peaceful occupation, and in some places put an end to it altogether. Very frequently the plant is found more to the west, among the springs of Tetung-gol and Etzyn-gol. The greatest quantity of rhubarb is collected there, and sent to Sining, the centre of the rhubarb trade. The drug is brought in the winter by beasts of burden, and in the summer by boat along the Hoangho to Tientsin, where it is sold to Europeans; but even there the price is six or seven times as much as in Sining. In former years most of the rhubarb was conveyed by caravans from Sining to Kiachta, the revolt of the Dungans made this route impracticable; but now that the rebellion has been trampled down in the blood of the rebels, the trade will revert to its old track. The root is cut in pieces, strung on a thread, and hung up to dry in the air, but never in the sun. In the Gansu mountains this valuable plant grows from the base of the deep ravines and gorges to the boundaries of the forest region, nearly 10,335 feet above the sea. In exceptional cases it is found still higher, but it prefers a valley with rich soil, and grows almost exclusively on the northern slopes, avoiding the southern side and all treeless places. In some districts rhubarb is cultivated; the root attaining its full growth in eight or ten years. A searching investigation into the physical conditions under which it thrives in a wild state led Przewalski to believe that it could be successfully cultivated in many parts of the Russian empire, particularly in the Amoor country, and the mountains of the Baikal, Ural, and Caucasus. He has brought over some seed into Europe, and it is to be wished that his hopes of success will be fulfilled. Above the forest region of the Gansu mountains extends the region of mountain shrubs and meadows. Prominent among the dense growth of shrubs, we find the rhododendron and prickly caragane. The alpine meadows, often small stretches of rich grass lying among the shrubs, are splendid in colouring; towards the end of June the mountain slopes are aflame with the pale yellow flowers of the cinquefoil, and the white, pink, and purple blossoms of the rhododendron. But the glory of this floral splendour does not last long. The rhododendrons and the prickly caraganes fade already in the beginning of July, and early in August the mornings are so frosty, that one herb-like plant after another shrivels up and disappears.

The fauna of Gansu is distinguished by its numerous birds; there are only eighteen sorts of mammals, and still fewer of fishes and amphibia. The poverty of amphibia, and especially of insects, is explained by the severity and changeableness of the mountain climate. The larger mammals are so hotly pursued by the hunters, that they are rarely met with, and as the country is thickly populated, they have not the necessary quiet and security to enable them to breed in safety. In spite of these unfavourable circumstances, a kind of musk (*Moschus moschiferus*) is frequently met with. Other ruminants are the Alaschan ibex, a stag, roe, marmot, and flying squirrel; while among the carnivora are a wild cat, bear, marten, badger, and our European wolf and fox.

The lake of Kuku-Nor is surrounded by steppes, of which the climate, flora, and fauna present a remarkable contrast to that of the adjoining mountains of Gansu. The incessant rain and snow which had harassed the travellers in the mountains, now gave place to splendid autumnal weather; but the forests and alpine meadows were replaced by salt, clayey flats, covered with prairie grass and herbaceous shrubs. Before long the antelope and the whistling hare were seen, and with them came the lark and the falcon. The wild ass (*Equus kiang*), called by the Tungus *Dochan*, is a fine animal, resembling the mule in size and shape, the coat pale brown, with pure white breast, black mane, and narrow black stripe across the crupper. It is remarkably quick of hearing, and very difficult of approach.

Przewalski made an excursion into north Thibet, crossing the salt morasses of Zaidam, where the camels began to fall lame, and the dogs' feet were so sore that they could scarcely tread. This is said to be the home of the wild camel, which differs but little from the tame animal. During rutting time the males are often very daring, and venture close to the caravans, when tame ones run away with them, and never return. This allows us, perhaps, to think that these so-called wild camels are only tame ones, which have escaped from their owners, and run wild in the sense that they recognise no master. But it would be interesting to know whether or no this really is the home of the "ship of the desert." The plateau of Thibet is bounded on the north by the mountain range of Burchan Buddha, which stands erect, like the giant guardian of the cold and desolate land. Iron frosts and terrible storms reign over it all through the whole winter; the spring brings also storms and drifting snow showers; the summer, incessant rain and frequent hail; and only during the autumn months is the weather fine, bright, and tolerably warm. A climate such as this is not favourable to vegetation. The soil, composed of clay, mixed with sand or gravel, is destitute of vegetable life. Only here and there a tuft of coarse grass, one or two inches high, rises from the unfriendly ground; and more rarely still a small tract of greyish-yellow lichen covers a space of a few yards. By the few springs of water a richer kind of grass is seen, and something that looks a little like a meadow lies between the bushy morasses which surround the spring. But even these oases bear the impress of the desert in their savage desolation. The vegetation of the meadow is composed of a kind of reed grass, about six inches high, hard as wire, and so dried up by the wind that it crackles under foot like dry wood, and crumbles into dust; indeed, the softness of this grassy carpet may be imagined from the fact that the thick soles of the camels' feet are often found bleeding after they have trodden upon it. Caravans pass this way in spring and autumn only, for in the winter snow is too deep, and in summer there is no fuel, since the dung of the yak, which is the only fuel obtainable, is softened by the constant rains. Even the spring and autumn journeys are seldom unattended by misfortunes. In these terrible wastes the animals die of the hardships imposed upon them by the climate. Camels and yaks are lost so constantly, that every caravan is accompanied by a reserve band of these animals, besides those which are really necessary for the transport of the goods. Sometimes, however, the misfortunes assume a more serious character. In the year 1870, a caravan, which left L'hassa in February, and consisted of 300 men, and more than 1,000 camels and yaks, lost all the animals, and about fifty of the men, in consequence of the terrible frost and snow. And yet, in spite of its barrenness and the hostile influences of the climate, the deserts of north Thibet are very rich in animal life. No one who has not seen it with his own eyes can believe in the existence of such an immense number of animals in such an inhospitable climate. The only way in which these masses of living creatures find existence possible is by constant migrations from one place to another in search of the scanty food offered them on the wretched pasture lands. On the other hand, man, the arch-enemy, is not there to molest them, and they live free from pursuit. The height of the plateau, and the consequent rarity of the air, renders the ascent of a not very steep hill, or a short walk along the level, fatiguing even for a strong man. Animals born and bred in the place do not suffer from the slight amount of atmospheric pressure, and breathe or run without painful exertion. The most characteristic among the mammals of Thibet are the wild yak (*Poëphagus grunniens*), the white-breasted sheep (*Ovis Polii*), the blue ibex, several species of antelope, the wild ass, the yellow wolf, the bear, the manul, an animal belonging to the feline tribe (*Felis manul*), the fox (*Canis vulpes*), the prairie fox (*Canis corsac*), the hare (*Lepus tolai*), the marmot (*Arctomys*), and two kinds of whistling hare (*Lagomys*). The animal most worthy of notice is the yak, which has been made sufficiently familiar by our zoological gardens. Were it not for the presence of this useful creature, every journey through these districts would be simply impossible, since its manure (for which the Mongols render special thanks to God) is the only fuel to be obtained.

Unfortunately Przewalski was forced most unwillingly to turn back as soon as he had reached the banks of the Blue River; and he complains bitterly that he was prevented from reaching the capital of Thibet, not from opposition on the part of the inhabitants, or difficulty arising from the nature of the road, but simply from want of money for the expenses of the journey.

He found himself unable to continue his travels far enough to meet the route taken by the brothers Schlagintweit; but from the reports of both travellers, it seems that no great novelty would have been found either in the flora or fauna of the country. The scanty vegetation ascribed by Przewalski to north Thibet seems equally true of the whole country. There are no grassy plains large enough to make any decided feature in the landscape to be seen throughout the land, not even in the so-called "pasture grounds" near Tibel, in the English part of Thibet, where small, isolated plants appear in the foreground. Near to Kaikurkur there is a wide valley covered with fresh green herbs—not grass, but low bushes belonging to several classes of non-coniferous trees, and looking like the European fir, except that they only rise a little way above the ground. It is a singular landscape, and reminds one of certain parts of the Engadine. The base of the Thibetian valleys often lies more than 15,000 feet above the level of the sea; and this great height more than counterbalances the nearness of the equator. Among objects of culture, we must mention barley, the chief kind of grain sown, beans (*Dāl, phaseolus auricus*) turnips, rice, and wheat; the latter is said to thrive well up to 12,000 feet above the level of the sea. Almost all the villages are surrounded by a fringe of orchards, and the lovely green of the fruit trees contrasts pleasantly with the bare rocky slopes on either side the valley. Lines of tall poplar trees rise between the fruit gardens, in which apples, pears, plums, apricots, and peaches, are to be found. The two latter fruits are very abundant, and finer than any we get in Europe. The domestic animals of Thibet are the yak, a small but excellent pony, the ass, and the mule; the latter, however, is rare, although the inhabitants have a high and even an exaggerated idea of its good qualities, and especially of its being able to work for a greater number of years than the horse, which grows old sooner. Camels, so plentiful among the more roving tribes of the Gobi, are not found here, and indeed the animal was so little known in central Thibet, that the camels belonging to Schlagintweit's expedition were with difficulty permitted to cross a bridge over the Indus on the road to Kaltse. It is only fair to say that this bridge was woven with osier canes, and that it measured ninety feet long, and was very old, so that the Thibetians were perfectly justified in fearing that it would break down under the weight of the heavily laden animals. Sheep and goats are very numerous. The former are killed for food, and their soft fine wool is a valuable article of trade. They are also employed as beasts of burden; especially the fat-tailed sheep, a white sheep, with a black head, and a tail from twenty to twenty-eight inches in length and width. The goat indigenous to the country is known even in adjoining lands as the Thibetian goat, and its hair is in great request for shawls, etc. The short wool, called *pashm*, used for textile fabrics, is found growing underneath the long bristly hair. We must also mention the dog and the cat. Farm-yard poultry were first introduced by travellers in the middle of the present century, close to the northern slopes of the Himalaya, while on the southern side many kindred species are found wild.

Cooper, who tried to find an overland route from China to India, describes the eastern districts of Thibet as poor in plants and animals, and yet as possessing many species of interest. The scenery from the summit of Tungulo, a mountain situated on the frontiers of China, does not look particularly attractive; bare, jagged rocks lay heaped together in chaotic disorder, separated by deep valleys covered with gloomy fir woods. The wild, sombre character of the scene was relieved by the vivid flashing colours of numberless birds of different kinds. Countless multitudes of crows appeared close below the snow line, some of them no bigger than blackbirds, and still lower were seen some wonderfully beautiful birds, with bright-blue bodies and wings. Two kinds of doves, one black, one blue, with a white tail, cooed in the woods, and the splendid pheasants were more numerous than in the best preserves. There were several species of pheasants, the *qua-qua-tuhi*, sprinkled with spots like the guinea-fowl, and displaying its tail-feathers like the turkey; and the *matschi*, with a white body, crimson head, and black tail. High overhead was heard the harsh cry of the ravens, birds of unusual size, that clove the air with the majestic flight of the eagle. While we are speaking of feathered novelties, we must not forget the large wild yellow duck (or goose), found on all the high-lying rivers and inland lakes of Thibet. These birds are exactly the same as the Brahmin ducks (Brahmin goose, *Casarca aurantia*), on the upper Brahmapootra. Cooper wished to possess a specimen, and shot at a duck, which he luckily missed, for a Lama who was with him ran up in the greatest excitement and told him that the yellow ducks were held sacred to the Grand Lama, and that it was considered a serious crime to kill one of them; and even to fire a shot at the consecrated bird was a misdemeanour. Unfortunately the sportsman, an agent of the Chamber of Commerce in Calcutta, was not a sufficiently good naturalist to pronounce upon the scientific name of the birds he saw in his travels, and we can only conjecture that they belonged to the splendid pheasant tribe (*Phasianus revesii*), and to the *Crossoptilon mandschuricum*, although his description does not entirely suit the latter.

Przewalski describes an interesting expedition across the desert of Gobi to Lob Nor. He started from Kuldscha on the Ili, which flows from the east into the lake of Balkasch. The valley of the Kunges was soon reached, and instead of the former scanty vegetation, the undulating steppe was covered with different kinds of grasses which grew thicker every mile. The outlying mountains assumed grander and wilder forms, and dark fir forests were seen upon their slopes. Non-coniferous trees grew along the banks of the Kunges. Black poplars eighty feet high, and from three to five feet in diameter, rose in regular lines, apple trees were abundant, birch and apricot rarer. The undergrowth was composed of whitethorn, honey-suckle, wild briar, snow-ball, and wild cherry. The numerous islands dotting the river were overgrown with reeds of different kinds, often interlaced with wild hops, while the tamarisk was seen in all places where the soil was sandy or gravelly. The grass which covered the forest meadows and the slopes of the mountains was mixed with dodder and bindweed, and often reached the height of five or six feet. In summer it is impossible to penetrate through this kind of thicket. The valley is famous for its beautiful fruit trees, especially its apricot and apple gardens. Here and there the ground was strewn with delicious apples which were devoured with much relish by appreciative bears and wild boar. A low mountain chain separates the valley of the Kunges from that of Zanma. Although the two rivers are only a mile apart where the pass leads from one to the other across the mountains, the difference in height between the valleys amounts to 2,000 feet. This is enough to explain why one would look in vain for apples and apricots in the Zanma valley, where the fruit trees are replaced by the fir and mountain ash. When the plateau of the Juldus and the adjoining tract of stony waste had been crossed, the traveller saw before him the boundless expanse of the deserts of the Tarim and Lob Nor. The soil consists here either of loose salt clay or drift-sand, and the organic life is poor and scanty. Przewalski describes the desert of Lob Nor as the wildest and most barren scenery of Asia, more desolate than even the desert of Alaschan. He remained eight days in this neighbourhood, because the forest land near the Tarim is rich in birds, and tigers are lurking among the tall reeds, but he never could even catch sight of one. He hoped to see on the Altyntag the wild two-humped camel, but could not shoot one. Twenty years ago they are said to have been numerous, but they are now much rarer, as the inhabitants hunt them down in summer and during the autumn months, lying in wait for them at the places where they come to drink. They seldom hunt these animals in any other way; for the chase along an unknown track is considered to be very difficult, and is only attempted by a few specially trained huntsmen. These men killed some for Przewalski, who came to the conclusion that these camels are really wild by descent, and not merely the offspring of tame animals escaped from servitude. The Tarim is a wide and important river when it first leaves its parent lake of Karaburan, but before it has flowed far on its course its waters dwindle and contract, partly drawn off into the numberless canals constructed by the natives for fishing purposes, and partly swallowed up by the encroaching desert which hems it in on either side, absorbs every drop of moisture with its scorching heat, and finally arrests its eastern course altogether. The struggle is then over, the river yields to the desert, life is extinguished by death. But the last effort of the baffled waters is seen in the wide reedy swamp known as the lake of Lob Nor. Dense growth of sedge and reed cover its surface, and round the stagnant waters is a fringe of salt marshes which destroy all vegetation, and finally blend with the true desert sand. Only a few tamarisk bushes are seen upon the southern shore, and the marshy reeds are trodden down by isolated tigers, wolves, and foxes. In the early spring the waters are alive with birds of passage, which fly to the lake as to a welcome resting place in their wanderings from the south northward.

We turn to a description of the western lowlands of Central Asia, starting from Teheran to Samarcand, *viâ* the desert of Turkestan, Khiva, and Bokhara.

"As the turbid waters of the Atrak," says Vambery, "would be the last fresh drinking water which we could hope for on our twenty days' journey to the shores of the Oxus, I advised all to avail themselves of the opportunity, and drink as much tea as possible. The tract of land beyond the Atrak, which forms the foreground of the great desert, is distinguished by the name of Bogdayla. We rode along a slightly undulating plain of tolerably firm sand until two hours after sunset. By degrees the sand ceased, and towards midnight we had a firm clayey soil beneath our feet, so that the measured tread of the distant camels sounded in rhythmical cadence through the silent night. Little worth recording was seen of either animal or vegetable life; we duly observed that the camels ate thistles, that gazelles and wild asses were seen, and that we came once upon some eatable turnips; finally, after we had begun to tremble at the thought that we had swallowed the last drop of fresh mud out of the water skins, and had not found any spring or stream, we arrived in Khiva. Khiva owes its reputation for beauty, not only to the sudden contrast presented to those who enter it straight from the terrors and desolation of the desert, but from its fine scenery and picturesque situation. Surrounded by turret-like heights, overshadowed by tall poplars, its rich fields and meadows charm even those who have wandered through the most beautiful scenery of Europe. If the eastern poets had tuned their lyres here instead of in the horribly desolate sands of Persia, they would have found more fitting subject for their raptures. Even the capital makes a favourable impression from a distance, rising with its minarets and cupolas from the midst of fruitful gardens. It is characteristic of the eastern landscape, that a tongue of sandy waste from the desert of Merv runs within a mile of the town, as if to heighten the vivid contrast between life and death."

From Khiva, Vambery made an excursion to Kungrat on the Oxus. The banks of the Oxus, between Khiva and Kungrat, are not particularly interesting; mountainous at first, they gradually sink to the level plain, and the travellers are incessantly tormented by the attacks of flies and midges, compared with which the gnats of the lower Danube are stingless butterflies. From Kiptschak a wood extends along the right bank, and continues with few interruptions beyond Kungrat. The land close to the bank is only accessible in certain places, between which it is composed of dangerous swamps and morasses. In some of the less densely wooded tracts hundreds of cattle are seen grazing, and there is no lack of game. Among the numerous wild animals, panthers, tigers, and lions are most dreaded. The country is thickly populated, and there is a large extent of cultivated land; as far as the eye can reach, nothing is seen but gardens, rising ground, and ploughed fields.

On his return to Khiva, Vambery continued his journey to Bokhara. The whole country as far as Chanka was highly cultivated, the road lay between fine mulberry bushes; and as the writer's ass took the lead in the expedition, his rider had plenty of time to enjoy the fruit, which was as large as the largest grapes. Turning aside from the river, the travellers reached the sandy desert. The eastern station bears the charming name of Adam-krylgan (the place where men perish), and a glance at the scene is enough to convince the wanderer that the title is merited. "Imagine," says Vambery, "a boundless sea of sand now rising in huge waves like those of the storm-lashed ocean, now gently swelling like the rippling surface of a quiet lake swept by a summer wind. No bird in the air, no worm or beetle on the earth, nothing but the traces of extinguished life—white bones of men and beasts lost in the desert; there is no horse in the world capable of travelling from one station to another in this hopeless waste, and the foreboding looks of the travellers shewed that even eastern fatalism was shaken on the threshold of the journey. The journey from Tunuklu to Bokhara was to take only six days, half of the way lying across the sand, and half across a wide, partially grass-grown plain frequented by shepherds. In spite of the scarcity of water, a scarcity so dreaded that even the sleepers held their water skins fast embraced, and in spite of the scorching heat of the sun, it was necessary to travel five to six hours a day to escape the fatal tebbad, or fever wind. At length, after a journey of five weary days, when the strength of the whole party was beginning to fail, the Chalata mountains came in sight. As the travellers approached them, the sand gradually diminished, and every eye was anxiously looking out for a herd of cattle, when a small cloud of dust was seen, and instantly every one alighted from his camel. The beasts knew well that the tebbad was approaching; they uttered loud cries of terror, and kneeling down stretched their necks along the ground, and tried to bury their heads in the sand. The travellers made use of their prostrate bodies as a protecting rampart, and had barely time to kneel down behind them when the wind swept over them with a hollow roar, depositing a layer of sand two inches deep upon them, the first grains of which burnt like a shower of sparks. If it had overtaken them only a short distance farther back in the desert, every man must have inevitably perished. The desert ended a few hours' distance from Bokhara, and Chakemir, the frontier town, was reached in two days."

A traveller (Grosz), who made the journey between Khiva and Bokhara principally by water, draws a very different picture of the scenery: "Scarcely has one turned one's back on dusty Khiva, when one reaches woods of very small trees, mingled with briars and undergrowth, fringed round their outskirts with leek and bulbous growths and many different kinds of bushes. The pleasant blossoms of the ranunculus and sword lilies on the damp margins of the marshes, with here and there the late blooms of the narcissus and anemones, refresh the eyes and spirits wearied with the heat of the day. The animal life is as varied as the vegetable life. Horses of noble race, but greatly deteriorated aspect, zebus, mules, camels, buffaloes, and oxen, remind one of scenes in Moldo Wallachia; prairie sheep wander through the pasture lands, proud stags frequent the meadows and the river banks, slender roes and deer, and hares in the pasture lands, fill up the rich picture of animal existence. Among the giant grasses which form the forests, and overshadow the river country, where the Amu canal joins the stream, rises the shrill cry of the marsh birds; herons, geese, grey and white swans, flutter across the surface of the water, or shyly move along the outskirts of the sedge. One day's journey leads the traveller to the river, where a rickety steamboat waits to carry him along the rushing waters. On the shore are seen the camps of the Usbeks, with here and there the ruins of fallen towns, but seldom any inhabited village. At times the eye meets nothing but rolling sandhills constantly changing and drifting before the wind. In a few places the sand is barren and incapable of bearing mosses or lichens, or too dusty to mark the track of the thirsty gazelles, or the stags, tigers, and leopards which steal over it morning and evening to find water. The farther one travels southward, the hotter is the tropical blaze of the sun, and the richer the vegetation growing near the river. In the evening the trees and bushes glide ghostlike past the sailing boat, and the howl of the jackals, foxes, and hyenas, stealing by the river-side, or through the darkness of the woods, accords well with the strange, weird night scene, and fills the traveller with mingled terror and delight. On the opposite side the willow branches bend and dip their slender rods deep in the water; behind a cluster of tiny islands, shaded by leafy plants and bushes, flows a shallow arm of the river, half choked with sand, the rippling waters murmuring in many a creek and channel covered by the broad floating leaves of the water-lily, and watering the tall grasses and the bushes of broom and coltsfoot and giant grasses which penetrate and undermine its alluvial bed with their fibrous roots. Inhabited places begin to appear before us. The journey down the Amoor is over, and we find ourselves in Kirki, seventy-nine miles to the south of Bokhara. The road leading to the town is beautiful; the hills on either side are broken by lovely little valleys, bright with the gay colours of flowering gentian, ranunculus, anemones, violets, sword lilies, chickling vetch and other kinds of vetch.

The road between Bokhara and Samarcand exhibits a high state of cultivation, and many signs of civilized life. Almost every two miles shews some little market town; and if it were not for the absence of trees, one might say that from the mountains, where all free vegetation ceases, this is the only spot where the traveller can enjoy a landscape resembling the cultivated scenery of the west.

If we consider this country only with reference to its oases and river scenery, we are justified in describing it as extremely fertile and productive. All kinds of cultivated plants yield a rich return, and the whole land would be an Eden of fertility if it had more water. Wheat is the principal kind of grain sown, and flourishes best where the fields have been most carefully irrigated by means of narrow artificial canals. When the wheat and other kinds of corn have been reaped, the fields are sown with beans, millet, Indian corn, poppies, and carrots. A drink called busa is made from the millet. The young cattle and the poorer among the inhabitants live chiefly on *djugara* or *holcus sorghum*, a kind of tropical grass. Barley is grown as food for horses; rye, lentils, and peas are not much cultivated. Flax is cultivated for its seed and fibre. Lucern, the principal fresh fodder, is sown on well-watered ploughed land, and mown three times in the year. *Rice* is extensively grown, although it does not thrive particularly well. Cotton and tobacco are also grown, and the latter is now being cultivated to the prejudice of the former, owing to the exertions of the new Russian settlers. The cotton crops are not successful, except in Central Asia, and are much inferior to the American produce, both in the length and firmness of the thread. Besides this list of vegetable crops, all kinds of garden produce is tended with great success. More than twelve different kinds of grapes are grown, some of them are made into wine, but the greater part are dried and sold as raisins,—a favourite eastern dainty. During the winter months the grapes have to be covered over to protect them from the frost. Apricots and plums abound; there are three kinds of peaches; the pomegranates of Khiva are famous, and the fig tree grows in every field. The pears are not very good, but there is a great variety of good apples. Quinces are boiled or baked; cherries are seldom sweet enough for a European taste. The mulberry tree receives special attention, because it yields very good fruit, and its leaves are used for silk spinning. Walnut trees grow wild in the ravines and mountain valleys; the nuts, as well as those of the pistachio tree (*pistacia lentiscus*), are used for making oil, but the resinous gum of the latter is not used. As to garden vegetables, the following familiar kinds are grown in large quantities: beetroot, turnips, cabbage, radish, leek, cucumbers, and pumpkins. More successful than all these, however, are the delicious, incomparable melons, which are famous even in Pekin; so that the Chinese Emperor has not forgotten to include among the yearly gifts demanded as tribute from the province of Chinese Tartary, a number of "Urkundschi," or melons from Urgend. Even in Russia these melons command a high price; for the merchant who takes a load of winter melons into Russia brings back to Khiva a load of sugar. Colour is lent to the Turanian landscape by the patches of madder, larkspur, and mallows, and by the quantity of cochineal. Every crop depends for its success upon the amount of water given to the soil; and the whole science of the Chinese gardener and husbandman consists in regulating the conveyance of the waters of the Amudarja, and bringing it to the plants at the right time. There are three inundations every year; the first, which takes place in February, is insignificant, the second and greatest happens in June and July, and corresponds to the melting of the snow on the upper Amudarja; the third occurs toward the end of August or the beginning of September, after rain has fallen on the Tamir plateau. The second inundation is the most important for Khiva—the field work is regulated according to it; the third exerts an influence on the sowing of corn. The harvest is generally over about the middle of August, for frost sets in during the month of September, and the waters of the Amudarja are frozen until the following February. Very little snow falls in Khiva during the winter, and the climate is therefore equally unfavourable to plants whose roots require to be protected in the winter, as to those which have need of a moist and temperate summer.

The fauna of Turan is not rich in a variety of species, but the existing kinds are extremely prolific; sheep, and principally fat-tailed sheep, and goats prevail; their number has been estimated at ten millions; besides these there are numerous camels, horses, oxen, asses, and mules. Among wild animals are found tigers, wild cats, gluttons, foxes, wolves, jackals, moles, hares, and wild asses. Neither the birds, reptiles, nor amphibia demand any special notice. The tame birds are fowls, with geese and ducks among the Russians; the wild fowl include wild ducks, pheasants, partridges, and bustards, which are sometimes hunted by the richer inhabitants with trained falcons. The fish of the Aral Sea, and the rivers which flow into it, are very important to the Russians and the inhabitants of the lower Amudarja; the waters contain sterlet, red bream, carp, and sturgeon. Besides these, all the waters of the steppes, even the salt pools, yield smaller fish, especially pike and bream. The drier districts of the steppes, particularly where the ground is clayey, abound with scorpions and tarantula; the sedgy banks of the lakes and rivers swarm with insects, chiefly gnats and horseflies. Sometimes immense swarms of locusts and crickets descend on the country, and devour the harvests. The industrious silkworm cannot often make up for the devastation worked by other kinds of insects. The dreaded black spider (*Latrodectus lugubris*), called by the natives *kara-kurt*, abounds in all the sandy districts of the steppes of Turkestan, but is found in such numbers in the city of Lombano, that the evil fame of the place has spread throughout the whole country. No larger than a finger-nail, and black as ink, it lives in the grass and on the sand, but is said to be able to jump for several feet. Its bite is fatal to horses and camels, and the Kirghis of northern Turkestan, who live by the small mountain streams of the Alexander chain, are said to lose numbers of valuable animals every year from the bite of this venomous insect. The popular idea among the natives is that the bite of the spider is equally fatal to men, but no European traveller has as yet been able to learn anything authentic on this point. The Kirghis declare that the insect cannot creep over anything woollen, and they never sit down on the ground without spreading beneath them the large kaschmah of felt, a practice adopted now by the Russian soldiers in Turkestan. It is not surprising that so little is known of this mysterious spider, since its celebrated European relation, the malmi gnat (*Latrodectus tredecim guttatus*), is just as little known. This terrible insect has been known in Tuscany since 1788, and is greatly dreaded on account of its poisonous bite, especially during the dog-days. It appeared in Spain in 1830 in large numbers, and again in 1831 and in 1841. Nevertheless, the peasants of the country will point out first one insect and then another as this poisonous gnat, and indeed his fear seems grounded more in superstition and ignorance than in the truth of close observation, since the effect of the poison upon the nervous and muscular system can be got rid of by copious perspiration during three or four days.

One of the most dangerous insects of the land of the Kirghis and the

POISONOUS SPIDER (*Galeodes araneoides*). Natural size.

Calmucks, nay, even from the south of Russia to Egypt and India, is the large spider (*Solpuga* or *Galeodes*). The bite of this spider often occasions the death of camels and sheep; and men who are attacked by it feel great pain, followed by violent inflammation, temporary paralysis, pains in the head, and fainting fits.

Mme. de Ujfalvy describes a scene witnessed by her in the town of Ture Kurgan. Early in the morning the servants were seen performing the different ablutions prescribed by the law in a small pond within the courtyard. The business-like earnestness and dignified seriousness of this action, with its regular prostrations and formal washing of the "seven openings of the head," the ears, eyes, mouth, and nostrils, were at first rather amusing to the uninitiated spectator; but when, immediately after the ceremony, water for washing and drinking for the travellers was drawn out of the same pond, they were unpleasantly reminded of the recent statements of the Russian doctors, who declare that the terrible prevalence of boils, and all kinds of skin diseases, arise in great measure from the use of this impure water. It is not only that in many parts of the country the water of the ponds is unfit for use; but there is no doubt that the unrestricted use of every pond that has the regulation depth of a few inches by people of all sorts, whether sick or healthy, for their five daily ablutions, is the chief cause of the terrible spread of such infectious disorders; for the germs of contagion are living organisms of animal or vegetable nature, and often of so minute a size that they are only discernible through a microscope. It is fortunately the custom in most of the Russian families living in Turkestan to boil all the water used in the house, whether for cooking or washing purposes. A terrible proof that this precaution is by no means superfluous was experienced by the inhabitants of Taschkend, where a few years ago a painful eruption broke out on the bodies of all those who did not boil the water before using it for the bath. This disease, called by the natives the Afghan disease, generally attacks children alone, gradually extending over the whole body, and leaving serious scars behind. In this year, however, every one, without distinction of age, who used the water from the ponds without boiling it first, and so destroying the animal organisms it contained, fell a victim to the disease. Another dreaded plague of the country is the guinea-worm (*Filaria medinensis*). It is not yet known whether this worm, which is both white and coloured in all the moist tropical lands except America, reaches the stomach by means of the drinking water, and thence penetrates the body like the trichinæ, or whether it enters through the skin from outside. But in either case, as soon as it has entered the cellular tissue, it grows to the length of three to four yards, and measures $\frac{2}{25}$ of an inch in diameter. Its presence in the system causes terrible and malignant ulcers. When the worm is seized in the open sore, it is wound over a little roller, an operation which takes several days, since serious inflammation would result from tearing the worm asunder. We turn gladly from the consideration of this unpleasant side of tropical life.

After all that has been said, it is not necessary to describe at any length the steppes on the shores of the Emba and Syrdarja, or those of the Ust-Urt, with their scanty vegetation of thistle, wormwood, orache, camel-grass, and saltworts; not a trace of running water is to be seen, but only a few salt lakes, morasses, and wells of bitter water; but the sedge which covers the shore on the northern side of the Caspian, and on the south-eastern side of the Aral Sea, deserves special mention because of its importance to the nomad tribes of Kirghis, who use it for fodder for their cattle in summer, and as a protection against the snow-storms of the winter; and although the countless swarms of insects prevent it from being a refuge to human beings in the summer, it still serves as a shelter for numerous wild boar and tigers.

We have still to speak of the Caspian Sea and the Aral Sea or lake. It has been said that the sea unites, and does not separate; but such is certainly not the case with the Aral Sea. The principal reason of its complete failure as a connecting link between the lands is found in the utter desolation of its shores, which do not, and apparently cannot, offer any settled home to man. Besides these, there is the scarcity of harbours, the difficulty of navigation at the mouths of the Amudarja and the Syrdarja, the once famous rivers Oxus and Jaxartes, now inaccessible to ships of any great size.

It is not wonderful, in the face of all these things, that the fishing trade has not attained the importance of which it is capable.

The southern shores of the Caspian attract many of the dwellers in the desert by the abundance of fish found in the waters near the coast. The south-western corner of the sea is the most profitable resort for the fishermen. The Turcomans catch sturgeon and many other kinds of fish in these waters; sometimes using the rod and line, and sometimes the fish-spear or fork. A very small part of the haul is kept by the fishermen for themselves, because they do not know how to preserve the fish through the hot weather; so that almost all finds its way into the markets of Astrachan. A peculiar denizen of the Caspian, the number of which diminishes more and more every year, is the Caspian seal (*Calocephalus caspicus*), an animal resembling the common seal in shape and size, but differing by the yellowish rings running across its back. The seal hunt is also carried on along the eastern shores, but with less success.

The official expedition to Merv, sent out by the Russians in the year 1879, transformed the desolate sandy shore near the south-eastern point of the Caspian into a temporary fair. The scene resembled a chaos of tents, carts, cattle-sheds, hay-ricks and huts. In the centre stood the tent of General Lasarew, crowned with the tri-coloured flag, and surrounded by the huts of his staff. "The camp extends across a sandy plain," writes an eye-witness, "where there is no standing well; the water which accumulates in ditches twenty-four to forty inches deep has an unpleasant salt taste, will not keep sweet for more than twenty-four hours, and is decidedly injurious to health. The heat of the day (113° Fahr. at noon) is bearable, considering the place; but the nights are so cold, that warm wraps and coverings are necessary. The chief means of transport is the camel, that stumbling-block in the way of every Russian expedition in Central Asia. The government of Trans-Caspian hired 4000 camels from the Kirghis at Mangaschlak for about £3 a month; but of these 1000 were killed by Russian balls; for the Tekts, after their retreat from Krasnomodsk, attacked the Russians, drove away the camels, and entrenched themselves behind the animals against the onslaught of the Russians. Moreover the Kirghis are very clever in outwitting the Russian government in their dealings with respect to the camels required for the campaign. The government promised a certain sum as an indemnity for every camel killed in the expedition; and a number of the owners appeared before the Russian officials, bringing in the tails of the slaughtered camels, and demanding compensation. When the promised payment had been made, it was found that the scoundrels had cut off the tails from the living camels."

Western Asia.

The territory which we intend to describe under the name of Western Asia comprises the Caucasus, Asiatic Turkey, Arabia, the Sinaitic peninsula, and the plateau of Iran. In a botanical point of view the garden part of this extent of country belongs to the region of the steppes; but almost the whole of Arabia must be classed as desert waste; and as the coasts of the peninsula, so far as they belong to the tropical zone, are covered with African flora, although possessing many special characteristics of Soudan vegetation, the coasts of Syria and Asia Minor belong to the Mediterranean region. The narrow tracts of coast land are not sufficiently extensive to arrest the wanderings of the animal world, and even that part of the country which belongs to the temperate zone is counted as part of the central zoo-geographical subdivision, while the southern part of Arabia, lying beyond the tropics, belongs to the east African. Of course the boundary lines of the various districts and regions are by no means as clearly defined in nature as they are upon our charts, so that we may very well consider the territory as a whole, particularly as the steppe region of Western Asia is divided into several distinct and sharply characterised floras.

The Caucasus and the mountain chains extending from Mount Elbruz to the Hindoo Koosh, separate western from central Asia. The rain which visits them, even in the hot season of the year, produces a little forest region between the steppes of the desert, with the distinguishing peculiarity that it is the crests of the mountains that are wooded, while the base and lower parts are steppes; indeed, it was across these very heights that many plants belonging to the north found their way to the Himalayas. The highest region is especially characterised by rhododendron, cranberry, and juniper bushes; a little lower down the copper-beech appears, first as a shrub, and then as a magnificent tree. Splendid elms and chestnut trees in the south; yew and alder trees are most frequently found in these forests, but they contain also oaks, maple, lindens, plane, birch, willows, fir, pine, and larch. As undergrowth are found whitethorn, apple, medlar, plum, cherry, gooseberry, hazel, mountain-ash, trembling poplar, yoke, elm, and juniper. It happens not unfrequently that the peculiar formation of the mountains prevents growth of forests to such a degree that the rhododendron and thorny shrubs are used as a substitute for fuel, alike in Daghestan and Ossetia.

Trans-Caucasus is divided by the Mesgian mountain chain into the districts of the Rion and the Kour. The former of these rivers belongs to the Black Sea, and its flora to the Mediterranean region; the latter flows into the Caspian, and widely different plants are reflected within its waters. The forests on each side of the Rion or Phasis, and those of Imeritia, Mingrelia, and Abkhasia, are much more luxuriant than those of Georgia, which is watered by the Kour. They contain numerous evergreen plants which are wanting in eastern Trans-Caucasus, such as box, azalea, holly, cherry, and laurel. The olive no longer thrives in Tiflis; but the woods of Calchis, copper-beech for the most part, contain a precious treasure of their own, the vine, which grows as a splendid climbing plant, with a stem as thick as a man's arm, reaching to the tops of the tallest trees, winding along from branch to branch, and hanging down from the woodland canopy its heavy bunches of grapes. The old classical methods are still in use for the vintage, just as we read of them in the writings of the Greeks and Romans, the division of the vineyards by cross roads pointing to the four cardinal points; covering the great two-handled pitchers with pitch, burying the wine flasks in the earth, etc. There grows the vine with small orange-coloured grapes of a sweet, aromatic taste and penetrating fragrance; there, too, is another kind, the berries of which yield a juice of such intense dark crimson that it can be used as ink. From this home of the vine, the tree whose fruit makes glad the heart of man has spread far and wide into other lands. But this royal gift of the forest must not make us forget the black date (*Kara churma*), the fruit of the lotus plum (*Diospyrus lotus*), which, like our medlar, is only eatable in a rotten state. These fruits are wanting in Georgia, but the latter country has nevertheless all the qualities necessary to a flora like that of Central Europe. The nearer we approach to the Caspian Sea, the more closely does the district assume the character of a steppe; and on the Aras, a tributary of the Kour, the artificially watered plantations near the valleys form the only oases among the barren steppes. The Caspian exerts, however, a fertilising influence on its southern side, because the heights of the Elbruz condense the watery vapours rising from the sea. In this place the coast is thickly wooded. Oranges, cotton, and sugar-cane are largely grown; even the date-palm is found, but the fruit of the latter is said not to ripen. The only thing recorded of the fauna of Trans-Caucasia is that the vegetation is often threatened by swarms of locusts. Thus in the year 1879 the district of Elizabethpol, an area of about 960 square miles, was visited by such a plague of locusts, that every inhabitant was ordered to destroy and send in about two hundredweight of the greedy insects; but the only result of this measure was to produce sudden fluctuations in the price of locusts.

Armenia is characterised on the whole as a highland steppe, and the character of the vegetation of Azerbijan and Kurdistan seems corresponding. When compared with the adjoining countries of Anatolia and Persia, it is rather at a disadvantage, owing to the cold of the winter and the lateness of the vegetation; but, notwithstanding its dry air, it is distinguished by its abundance of water. The winter generally lasts from October to May, that is, eight entire months: the transition to summer follows quickly upon the melting of the snow; but the short duration of heat, corresponding to the period of vegetation does not allow of any forest growth which deserves the name. It is only on the mountains of the outskirts that woodland tracts are found. Large areas are overgrown with tragacanth, gum trees, and prickly leadwort. This country, consisting of highland steppes or Alpine grass lands, which seems to be accessible, by its height and formation, to mountaineers only, and which, now that its original inhabitants are scattered, is roamed through by nomad tribes, nevertheless participates in the civilization of an agricultural land of European culture, thanks to the water flowing through its numerous rivers, and the quick ripening of the harvests, assured by the hot summers and fine, clear skies. Under these favourable circumstances the wheat crops near Lake Van reach up to 6,600 feet above the level of the sea, and those of the plateau of Erzeroum to 5,900 feet, and amply repay the cultivator, while in the cloud-capped height of Goktschai already at 5,580 feet, even barley does not always ripen. On the high plateau near Lake Urumiah, cotton, sesam, and even rice are grown; figs thrive in sheltered places, and the vine flourishes along the shores of Lake Van, to a height of about 5,580 feet above the sea; but wherever either the snow from the mountains, and the rivers which it feeds, are wanting, or the formation of the ground presents any obstacle to irrigation, nothing is seen but barrenness, desolation, and poverty. The luxuriant green of the garden grounds round Erivan is intersected by countless trenches of water, and picturesquely shadowed by the silvery foliage of the oil-willow hedge (*Elaeaginus*). The straight lines of the pyramid-poplars, often planted in double or even triple rows, are relieved here and there by clusters of fine elms. The grassy soil of the gardens forms the floor from which countless apricot trees rise and spread abroad their wide branches. In the fields, cotton, castor-oil plant, and rice plantations blend in beautiful shades of green. Rich life abounds throughout the scene. There is no lack of colour and movement in the foreground of this picture. Lazy buffaloes drag the heavy waggons, whose covers of bright-coloured cloth protect the inmates from the scorching heat. The gardens are full of busy groups, for the silk harvest has begun. Twelve yoke of oxen drag the heavy ploughs through

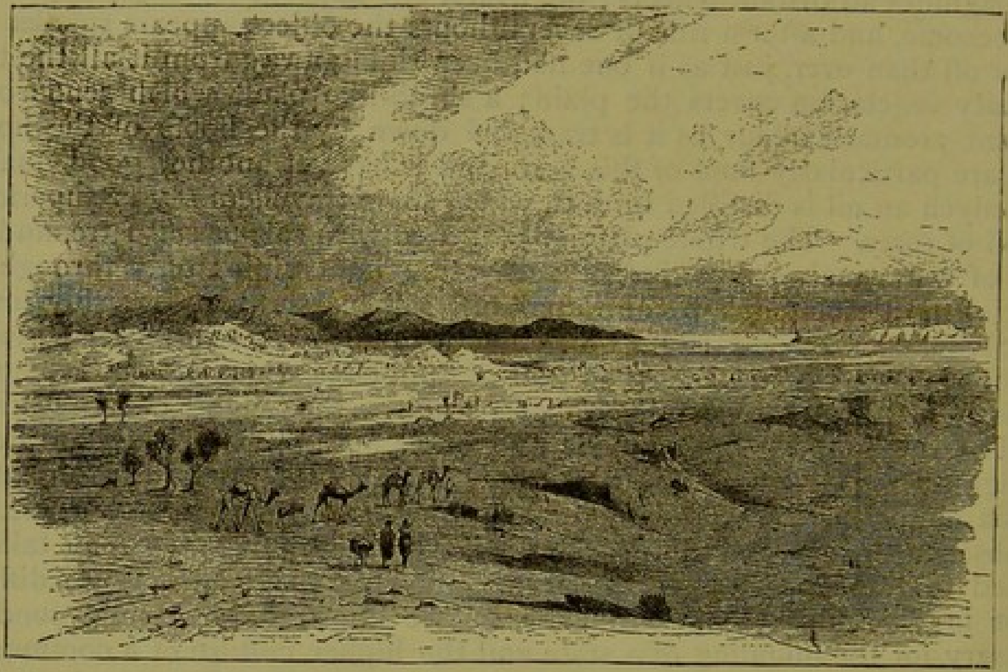
SEA WRACK OFF THE FALKLAND ISLANDS.

the hard clayey soil. A flight of starlings flits past to settle down upon the ripening mulberry trees of the nearest garden.

The plateau of Anatolia, the interior of the western half of Asia Minor, possesses a climate resembling that of Spain, and much less continental than that of the steppes in general. Lying at an average height of 3,000 feet, it gradually slopes down toward the Egean Sea on the west; and as several river valleys run from the interior toward the coast, the vegetation of the plateau gradually merges into that of the Mediterranean region, separated in the south alone by the heights of Mount Taurus, which is bounded by the salt plains of Koniyeh. The plain extending from Akserai to Koniyeh is more like the ocean than the land; for ninety miles the traveller sees neither tree nor shrub, and within many miles there is no village, house, or ploughed field. It is one of the most level plains of the world, and only on the distant horizon does the pale blue streak of the mountains seem to float in the air. The mirage raises and magnifies all distant objects; the nearer one approaches them, the smaller they become, and after a ride of several hours the object appears smaller and farther off than ever, just as if one had been riding away from it all the time. A scanty vegetation covers the plain; a shrub-like plant which sends out a pleasant aromatic odour as it is trampled down by the hoofs of the horses. Cows are particularly fond of this herb, and it has yet another good quality: in Koniyeh an oil is distilled from it, which some travellers say is superior to any oil of roses. The whole plain is saturated with salt or saltpetre, and the want of water makes any kind of cultivation impossible: only through the midst of the desolate plain the waters of a salt marsh flow sluggishly toward the salt lake of Koch-Hissar, which has no outlet. The mountain flora of Anatolia is everywhere richer than that of the plains, which are deprived of the fertilising breath of the moist south-west wind by the heights of the Taurus.

The ruins of the Lycian cities and other antiquities give us an idea of the high degree of civilization which prevailed in past times on the plateaus of Asia Minor, now traversed by nomad tribes and their herds of cattle. In the absence of any exhaustive description of the climate, we may take for granted that the neglect of regular irrigation rendered agriculture difficult, if not impossible, and agriculture is, as we know, the principal condition necessary for the founding of a state and the higher culture of a community; for it is not until those duties which among nomadic tribes are incumbent upon every family are distributed among the various members of a corporate state, that men of genius and capacity for action have scope and leisure to develope their gifts, and bring forward those political and religious ideas to whose influence we owe the marvels of art and architecture, the monuments of heroes and temples dedicated to the gods, which yet remain to testify to the vanished aspirations of the earlier inhabitants of this beautiful country. It has been supposed that the present sterility of the land is caused by the cutting down of the large forests, but a closer study of the subject inclines one to the belief that it is the indolence of the present inhabitants which is to blame, and that, if they could be roused to exertion, the re-awakening of the East might again be hoped for. Moreover, the Taurus mountains, which form the boundary of the high table-land both on the south and on the east, are still covered with extensive forests, and even the northern mountains by the Black Sea are not destitute of trees, while the heights of the interior are entirely cleared. But even now there is no lack of centres of civilization in the interior of the table-land of Anatolia; for instance, the opium trade of Karahissar, the important industries of Angora and Koniyeh, and the commercial activity of Cæsarea. Even on the desolate plateaus of the ruined Lycian cities *corn* is grown, and the *vine* is cultivated. The inhabitants of the lower lands, arranged in terraces round the coasts, resort during the summer months to the mountains for that purpose.

If we turn from the contemplation of the interior of Asia Minor to study the Mediterranean flora of the coasts, we find much to admire. The flora of the coasts of the Black Sea resembles that of the western Caucasus, but in addition to the trees of the latter country, we find large cherry trees with fruit partly bitter, and bitter and partly sour; sometimes apple and pear trees. Among the luxuriant undergrowth are several new types; *figs* (*Ficus carica*), laurel, dwarf almond, and hazel, with other fruit trees attractive to the youthful imagination. Rye has been seen growing wild, and ought to thrive well under culture. Among the plants cultivated on the west coast are rice, tobacco, sesam, poppy, cotton, and madder; in the lower lands are



PLAINS OF TROY.

olives, figs, oranges, mulberries, carob, evergreen oaks, plane trees, and fir, while above them grow pines, cedars, junipers, maple, ash, chestnuts, etc.

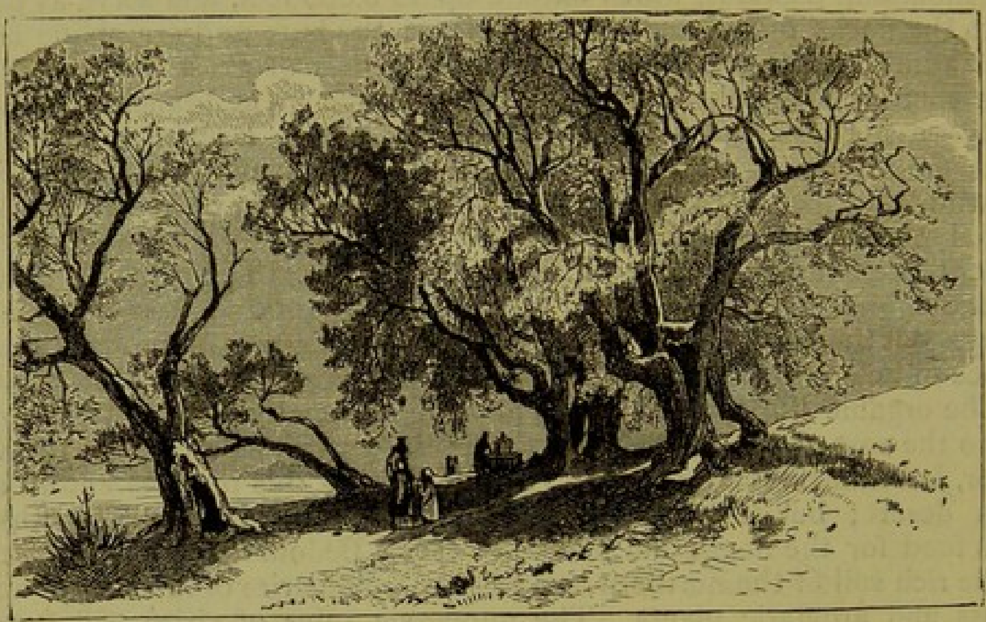
In the year 1879, the trade of Trebizond and the neighbourhood was reported upon by the resident vice-consul, and his statement confirms the old classic story told by Xenophon, how many of his soldiers fell ill after partaking of wild honey from the valleys near Trebizond. The modern report states that the valleys are visited by numberless bees, but that no one eats the honey which they collect. If a stranger inadvertently tastes it, he suffers from giddiness, diarrhœa, and loss of consciousness, frequently followed by death. Bees are kept only for their wax. The reason of this poisonous quality of the honey is found in the presence of the deadly thorn apple (*Datura stramonium*), which grows in abundance throughout the valleys, and from whose blossoms the bees gather large quantities of delicious, but poisonous honey. On the heights, where this plant is not found, the honey is pleasant to the taste, and perfectly innocuous. Poisonous honey is found in other districts where poisonous plants grow freely.

The description given of the south coast of Taurus in Cilicia is that of a rich and fruitful country. There is a wide field for agriculture, for among other plants which thrive readily we find madder, cotton, sesam, corn.

rice, figs, citrons, oranges, peaches, apricots, pears, medlars, plums, apples, pomegranates, grapes, olives, date palm, pistachios, mulberries, almonds, melons, cucumbers, pumpkins, and jujubes. The formation of the mountains is favourable to the growth of vegetation, for they only rise as a background to a wide hilly country, whose undulating slopes are richly cultivated. The traveller enters this hilly country through woods of fine oak trees. Shaded in the south by the shrub oak, it is intersected by numerous furrows and valleys. The heights are covered with thorny shrubs; and where the ground rises more steeply, and is cut through by narrow, precipitous ravines, the rocky steeps are shaded by the dusky blue-green of the fir. Below lies the vivid green of the woodland valleys, brightened by many a village, field, and orchard. The wild mountain heights accord well with the sombre green of the black fir, cedar, and juniper trees (*Juniperus excelsa*) which grow to the height of 5,900 feet above the sea level. The ravines are often 900 feet deep. The wanderer in the valley sees above the tree line the bright emerald of the mountain pastures, which extend up to 8,000 feet, and serve as pasture land to the flocks of various nomadic tribes; the bare and crumbling heights do not admit of the growth of continuous patches of grass. The formation of the country is highly favourable to the three great branches of human activity—cattle rearing, agriculture, and navigation. Even the hunter finds objects for his daring and endurance in the ibex, black-eared lynx, Syrian bear, wild boar, panther, jackal, and hyena; and as king of birds he seeks the splendid pheasant-like bird (*Tetraogallus Caucasicus*). These are the characteristic representatives of the fauna of Asia Minor. The camel is used as a domestic animal, and there are said to be about 50,000 of the species in this country. But there are exceptions to these glowing pictures of the coast scenery; no trace of beauty or fertility must be looked for upon the plain of Troy.

The organic life of Syria and Palestine, especially that of the countries lying to the east of the Orontes and the Jordan, which flow through the valley of Chor, is but little known. The greatest part of this plain is known as the Syrian desert; but it is not destitute of rain in the winter months, and affords food for the flocks and herds of several Bedouin tribes. It is known that the rich soil of the northern and western boundaries of this steppe abound in grass and aromatic plants. The numerous ruins of cities still found on the high table-land of Hauran bear eloquent testimony to the fact that a high degree of civilization once prevailed; and even now corn is grown here and there in the countries to the east of the Jordan, where the rain-water is collected in tanks, and used to irrigate the land. If the supposition can be confirmed, that many of our bread-stuffs grow wild in Hauran, it seems to indicate that in past ages agriculture must have already been carried on here. An acquaintance with the flora of the countries lying to the west of the valley of Chor teaches us that the Mediterranean flora is found upon the sea coasts. Between the coast of Beyrout and the plain of Damascus the chains of Mount Lebanon separate the coast flora from that of the interior more abruptly than is the case farther southward, where there are no lofty heights, and the plateau of Jerusalem rises in terraces from the plain. The transition from the Mediterranean to the Syrian flora is strongly marked in the north, between Antioch and Aleppo. The sudden change is not, however, due to any alteration of temperature, which is nearly the same on the high table-land of Palestine as it is on the coast; but to the increasing dryness of the air, which loses its moisture as it approaches the interior of the land. The nearness of the sea and the presence of the great Arabian desert combine to exert an influence upon the climate and vegetation of Palestine, in consequence of which the rainy season in the north happens during the winter months, and brings down much more rain than the south receives.

Judæa is known in sacred and secular descriptions for rocky, barren heights, and near the Dead Sea the landscape assumes the character of desert scenery. Bare rocky ground, slightly covered with earth only in the deep ravines, such as the narrow precipitous gorge below the Convent of Saba, where the rock falls vertically to the depth of 1,230 feet, and the brook of Kedron flows through the valley, which is only a few paces wide. The culture of southern Europe, for which we will choose as representative plants the olive and the vine, is only possible in the valleys watered by flowing streams. Samaria, on the other hand, has a luxuriant vegetation, and many of its mountains are clothed with woods to the summit. On the promontory of Djebel-Nabud, the traveller finds pleasant valleys rich in beech woods, frequented by gazelles, and alternating with rich meadow lands. Beech and evergreen oak grow side



Olive Tree (*Olea Europæa*).

by side along the slopes of the chain leading to Mount Carmel. Beyond the mountain chain of Galilee the same characteristic is still more strongly marked, for Tabor is covered with woods to the summit, and the valley of Kishan is noted for its rich garden soil. The whole district is highly cultivated, watered by noble streams, and luxuriant with a southern abundance of vegetation, while the hillsides are covered with rich pasture lands. The mountain chain of Adschlun, in Perea beyond Jordan, is noted for its pistachio and arbutus (*Arbutus unedo*), and for its fine oak woods. The arbutus is also called the strawberry tree, but its fruit is more like the sloe than the European strawberry, and indeed Pliny tells us that it is called *unedo*, because no one would willingly eat more than one of the berries.

It has been maintained by many learned and travelled writers, that Judæa is a poverty-stricken, bare, and desolate land, lying under a visible curse, and having nothing to shew of the fertility which once won for it the title of a land flowing with milk and honey. Such, however, is not the case. Palestine is still a fruitful country, and if it were diligently and intelligently cultivated, would be found most productive, as was sufficiently proved by the harvests of 1868. The fertile plains of Gaza, which extend to the foot of Carmel, and thence from Acca and Bashan to the Sea of Tiberias, are admirably adapted for wheat crops, and the heights from Djenin to Hebron produce a good yield of vines and olives. In the valley of the Jordan the vegetation is tropical in its luxuriance, the black soil is fitted for cotton and sugar-cane plantations; while the districts beyond Jordan, now beginning to be thrown open to commercial enterprise, were famous in antiquity for their fertility. They will never produce a great variety of objects of culture; but all the kinds which are now insufficiently cultivated, such as wheat, barley, sesam, cotton, tobacco, vine, and olives, to which we may add maize, castor-oil plant (*palma Christi*), and millet, may be more plentifully sown, and yield far larger and richer harvests. We must, however, confess that the attempted colonization of Palestine by Europeans, and especially by Germans, is greatly hindered by the indolent hostility of the Turkish authorities, and by the climate, which is trying to most European constitutions.

But it is not possible to sketch the characteristic outlines of Palestine with a few hasty lines; it is more than a spot of some hundreds of square miles in a country partially covered with steppes; it is to hundreds of millions the "Holy Land," and well worthy of detailed description. How often has it been described! and how contradictory are the descriptions given! By far the greater number of travellers tell us little or nothing of the actual facts; but content themselves with pouring forth the emotions awakened within them by the memories aroused by the different places on their route, or in complaining of the hardships attending travel in the East, and in descriptions of the misery of the country. To one, the Dead Sea presents nothing but the scene of a righteous curse which heightens and deepens all the terrors of the gloomy place; another depicts the scene as less terrible than his imagination had fancied, and not destitute of a savage beauty of its own; a third looks upon it only as a bathing-place for the weary traveller, and devotes all his attention to discovering whether or not the water is really so salt that a man cannot sink in it; others, again, indulge in speculations as to whether the salt of the waters could or could not be turned to account; and the same diversity is noticed in the description of other places of interest.

Hepworth Dixon tells us that the town of Bethlehem cannot boast of any extensive outlook. On every side but one the prospect is barred by some mountain peak or jutting rock. Mar Elias, and the Greek convent on its summit, shuts out the view which is sought first of all by every eye; namely, the road to Sion, and the Mount of Olives. A succession of gardens, a few precipitous fields, a place where several white roads cross each other, a mountain-valley which descends in terraced steps toward the great vale of Kedron, make up the landscape. And yet the mountain, hemmed in by higher peaks and neighbouring crests, has its own enchaining beauty. Doubtless the charm owes something of its power to the rust of sacred memories awakened by the place. Who could look down unmoved upon the fields where Boaz reaped his corn, the hillside where David tended his sheep, the road along which the blessed Virgin and St. Joseph wearily journeyed, or the place where the shepherds kept watch over their flocks by night? But even to those who visited the scene in ages past, this fair and fruitful mountain-side, with its springs of fresh water, and its large oak woods, must have appeared beautiful. If we look toward the south and the east, we see its gardens basking in the noontide heat, and its white houses bathed in a dazzling light, as if they were on fire. The vine, fig tree, and olive flourish kindly in the rich soil; the grapes have a sweet, aromatic flavour, and the green figs of Bethlehem are so delicious, that those who partake of them think of them as the Egyptian does of the waters of the Nile. A dark-red loam, called by the Arabians "the good earth," lies shining in the clefts and furrows of the rock, ready to receive and absorb the refreshing autumn rains. Fields are so scarce in this inhospitable zone, that the few grassy patches which disappear near the desert, lend to this region a friendly character, and win for the town a name of good omen. The old name Ephrath means fruitful place, and Bethlehem, the house of bread. The cart-ruts and narrow mountain paths, though whitened and scorched by the desert sun, shew many a pleasant shadowed nook in their rocky caves or fruitful orchards.

Galilee, observes Hepworth Dixon, has always been famed as the Garden of Syria. Everything thrives within its borders, from the Caspian walnut to the Egyptian palm. While the hills of Judah are bare and rugged, and the plains of Sharon parched and burnt, the wadies (mountain gorges) of Galilee are bright with herbs and flowers. The sides of Mount Carmel are clothed with oak woods; cedar groves nestle in the clefts of Hermon; myrtles grow to the height of trees, and the air is filled with the scent of orange blossoms. Every hill is a *vineyard*, every valley a *cornfield*. Sunny as the delta of the Nile, picturesque as the garden scenery of Granada, bright and green as the far-famed oasis of Damascus, the hot sun and life-giving rain work together, and the waters flow through Galilee, not in cisterns and tanks, but poured out seaward in noble streams. The road from Acre to Nazareth lies over a stretch of old Roman pavement, which reminds the traveller of the Campagna; then comes a broad camel track, succeeded by grass land, thorny bush, and rough, rocky paths. Hidden away amid a cluster of low hills, covered from foot to crown with vines and fig trees, lay a natural hollow of red and white earth, star shaped, about two miles in width, and exceedingly fertile. Along the steep and chalky slope of the highest of these hills winds a lovely valley, which, in a country where every stone seems to have a history of its own, is distinguished by possessing no world-known legend and no native name. But its fields are full of wheat and barley. Round the valley lie a ring of gardens fenced with loose stones, where myriads of green figs, red pomegranates, and golden citrons ripen in the summer sun. High up the slopes, marked out and planted like those of Bingen on the Rhine, hung clusters of purple grapes. Among the corn in the valley, shaded by fig and mulberry trees, daisies, poppies, tulips, lilies, and anemones grew in rich abundance and dazzling play of colour. Near the foot of the hillside a well of sweet water bubbled forth, strong, clear, and cold, and above this living spring, scattered in a straggling street which led to the synagogue, rose the dwelling of many a shepherd, workman, and vine-dresser. The Greeks gave to the place the name of Nazareth.

Jerusalem lies in a barren and waterless district on a chalky table-land rising within a belt of mountains; the plateau is connected with the high table-land only on the northern side; deep, precipitous valleys cut it off on the south-east and west; it represents itself as a series of white walls, above which stand forth a few cupolas and minarets, mingled with the dark green of the cypresses. Bare mountains and chains of hills covered with ruins stand round about. To the east of the city runs the Kedron wady, the mysterious valley of Jehoshaphat, with its scattered olive and fig trees, barren and bent with age. Ghost-like, they harmonize well with the weird aspect of the ancient gorge, "the valley of the shadow of death."

Leaving behind him the camel track which leads from Bethlehem, the traveller enters the desert, and rides eastward: the path lies down the mountain ravine, steep as a Gothic roof, now climbing for a while across stony hills, now leading up the chasm of some dried-up watercourse, but keeping always its main direction, and sloping sharply down towards the valley of Bahr Lut, the Dead Sea. The aspect of the scene changes at every moment before our eyes. It is not only that as we draw nearer to the desert the land becomes whiter, stonier, and more parched, that gardens and herds of cattle are more seldom seen, that the sentinels cease their rounds, and the tracks are lost, but that within the space of an hour or two the trees and plants are altogether different from those he has left. On the western slope the vegetation was home-like and familiar, interspersed with the flora of a warmer clime. In the valleys round Ain Karim the dwarf oak, bramble bush, rock rose, and arbutus grow in the same soil with the fig tree, olive, carob, and vine. Upon the high ridge which joins Jerusalem to Hebron, the plants of our European woods and fields cease altogether. The dividing line is sharply drawn; for the plants grow right up to the gates of Jerusalem, and there halt suddenly, like an army on its march. Not one of these plants, we are told, is found upon the Mount of Olives. The olive is seen for about an hour's ride farther to the east, and so are the carob and the lentisk; but these plants do not flourish beyond a line which may be drawn between Bethany and Beit Sahur. Even among herbs, rue, tamarisk, and broom are almost the only familiar names. The desert of Judah, if it may be said to have any flora, has one of its own. Salsolas, fagonias, zizyphus (or Jew's thorn), alhagi, artemisia, mugwort, and wormwood, struggle for a precarious existence between the stones of the shaded ravines. For many miles no house nor man is seen; but many a vulture and fox rise, at the traveller's approach, from their prowling round dead camels and asses. In a dry well lay a leopard, which had fallen in and perished. For how long a time the blue sparkling waters of the Bahr Lut flash and shine before the eyes! They seem fairer than the tenderest alpine lake seen from the mountain-top. A spring of brackish water leads to a thorny copse, a forest of canes, oleander, agnus castus, prickly bush, and bramble. It is a strange scene. Lofty mountains on the east and on the west; on the right the sea, on the left the ruins of Gilgal and Jericho, in front a level plain of sand and rubble, and the green margin of the Jordan. Not a cloud in the sky, not a stirring in the ripple rising on the sea. No bird's voice, no hum of a passing insect breaks the death-like silence. The sun glares mercilessly down upon the sand. Here and there along the coast lie the trunks and fragments of ancient trees, world-old giants torn by the floods from the banks of the Jordan, and dashed down into the briny lake, hurled back again by tempests from its thorny clutch thickly encrusted with salt. Vultures fighting over a dead camel rise from their feast to watch the travellers bathing in the sea; their fiery eyes never averting a baleful, vampire-like gaze from the sight of the white flesh, until the intruders have ceased to splash and dive round the rocky islet. Travellers vie with each other in describing the beauty of the Dead Sea. "Beneath our feet," says Fraas, "lay the mysterious lake, a sheet of incomparable blue. In the deep stillness of the scene, broken only by the short cadence of the lark, we heard the breaking of the surf below, and saw the sapphire waves crested with silver foam. A frame of tender green circled the blue waters; and the pale-yellow chalk cliffs, darkening to brown under the touch of wind and weather, contrast, in their cold, stern beauty, with the charming landscape in the background. Fish has hitherto not been found in the waters of the Dead Sea.

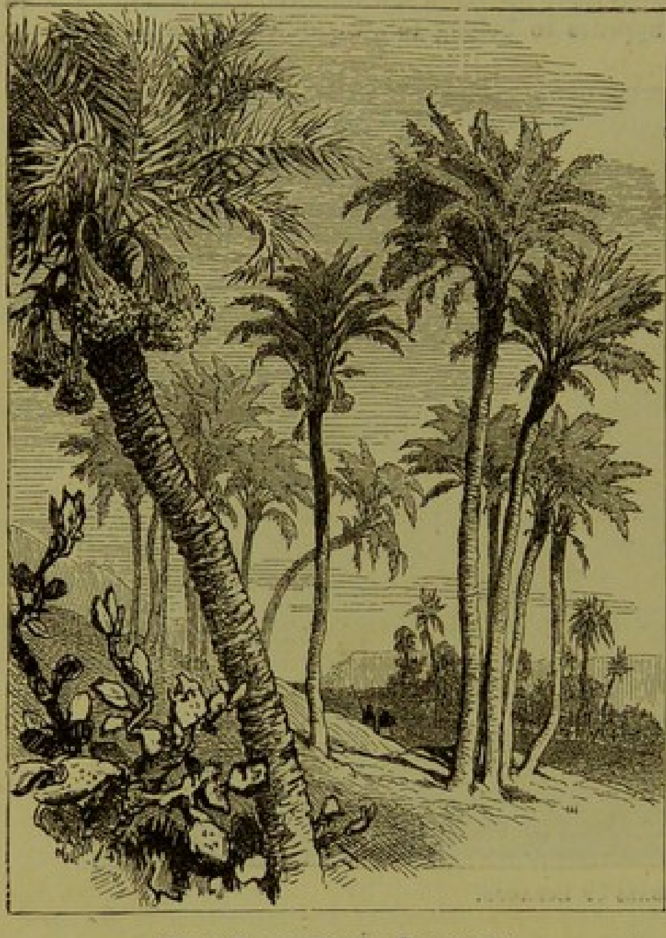
One of the most interesting scenes in Palestine is the cedar-covered Machmel, the third in height of the peaks of Lebanon. This mountain is 10,000 feet high; its broad and lofty cedars wave their crests from afar, and under their dark shelter the clear waters of the Nahr Kadischa spring forth from the deep rock basin. The mountain gorge begins in the region of the cedars, cuts through the whole side of the mountain, and comes to an end on the sea shore near Tripoli. Naked and scorched, the rocky walls rise high on either side, in wild, fantastic outlines. Between the dark rocks, the cedars on the whitish sand plains of Machmel appear at a distance like insignificant shrubs. But when, upon a nearer approach, the traveller finds himself beneath their shadow, their true proportions are seen, and the awe-inspiring gloom is felt by all. Although there are but a few hundred trees standing upon one or two acres of ground, the scenery appears to belong to a boundless forest, an illusion

Cedars of Lebanon.

heightened by the undulating character of the ground, which promises an endless extent to rise and fall behind every fresh hollow reached in the ascent. The trees have often been counted; but the results, as given by travellers, are so contradictory, that one is inclined to believe in the truth of the popular saying, that the number of cedars of Lebanon can never be told. Burckhardt counted eleven or twelve of the oldest and finest trees; then five-and-twenty very large ones, about fifty of moderate size, and more than three hundred smaller and younger ones. The difficulty of arriving at an accurate result arises from the fact that many single trees have two or three trunks, so that on one expedition Dandini counted three-and-twenty large trees, while one of his companions only found one-and-twenty. Another authority says that, if all these "twins and triplets" are counted singly, the forest will be found to consist of 377 trees. The same divergency of statements exists with reference to the diameter of the largest trunks. In the year 1737, *Labillardière* writes, that the largest tree measured twenty-four feet in circumference. A later traveller, on the other hand, estimates the circumference of the seven largest trees as forty-six feet; but he probably includes in this measurement the roots and outgrowth of the trees. However this may be, all writers agree in describing their unusual size and appearance of great age; and some go so far as to say that these very trees may have been living in the days of King Solomon.

Decandolle contradicts this statement, saying that the oldest cedar has not lived for more than 800 years; and Hooker, who founds his theory upon the number of annual rings which he counted on a branch of a very old tree, says that no tree now upon Lebanon is more than 500 years old.

The plants of Palestine, especially those of the Bible, have been the objects of close, if not of altogether conclusive, examination. Among the least known we may mention the turpentine tree (*Pistacia terebinthus*), a plant resembling our walnut tree in its feathery or pinnated leaves. *Hyssop* is, according to Griffith, the common caper bush (*Capparis spinosa*), whose unopened flower-buds are the capers. The poplar tree mentioned in Genesis is said to be the storax tree (*Styrax officinalis*); and the pious fathers of Mount Sinai say that the burning bush was the blackberry bramble, or *Rubus sanctus*. The palm is the date-palm, of which we shall speak later on. These plants belong to the Mediterranean flora, while the zizyphus (*spina Christi*), Jonah's gourd (*Ricinus communis*), and the apple of Sodom (*Asclepias*, or *Caloptris procera*), belong to Arabia and Sahara. The balm of Gilead is thought to be the narrow-leaved oleaster (*Elæagnus angustifolia*), the lily is the scarlet lily (*Lilium chalcedonicum*). The apple of Sodom, the *Oschur* of the Arabs, is a tall, slender plant, with egg-shaped leaves, hairy on the under side, and purple flowers: the fruit is said to be the mysterious apple of Sodom, which appears fair and pleasant to the eye, but, according to Josephus, still contains signs of the Divine anger in the dust and ashes with which it is filled. It is true that it looks something like an orange, and upon being pressed bursts with a snap, and only leaves in the hand a few fragments of skin, and some long hairs surrounding the seeds. Other writers think that the apple of Sodom is the nightshade (*Solanum sanctum*), whose fruit is very often worm-eaten. The oil of Jericho is obtained from the fruit of a plant of the balanites order.



DATE PALM (*Phœnix dactylifera*).

There is not much to be said with respect to the fauna of Palestine. Samson and David slew lions; but these animals are not met with in the present day. Leopards, wolves, jackals, foxes, hyenas, bears, wild boars, gazelles, and stags, are still found. Among birds we find many kinds familiar to ourselves, such as partridge, quail, stork, sparrow, lark, nightingale, raven, vulture, etc. Snakes are rare. In the Sea of Tiberias, shad and a kind of bream are caught, with many other kinds.

Mesopotamia, once the garden of the world, is now a dreary waste and solitude. A clear bright sky arches over the land all the summer through. Westerly, and especially south-westerly, winds, coming from the hot parched table-lands of Arabia and Syria, blow without cessation; the air is dry, and the scorching sun of Bagdad raises the summer temperature to 113° Fahr., a reading equal to the temperatures of tropical east India, Sahara, Arabia, and Persia. In the winter the north-west winds bring with them a little rain, and make it possible for the steppe to clothe itself with flowers for a short time, but the blossoms soon fade and pass away. "The plants begin to germinate," writes Ainsworth, "at Mosul in the moist month of February, and bloom through March and April. Before the end of May, everything, except the dry artemisias and mimosas, wither and remain dead until the following year. No cultivation therefore is possible, unless the ground is carefully watered by artificial irrigation. Where this is done, it yields good wheat crops and fine trees. The spring flora is principally composed of bulbous plants, such as amaryllides, lilies, arums, orchids, etc.; the later flora comprises prickly centaureæ, hairy artemisias, and aromatic labiatæ.

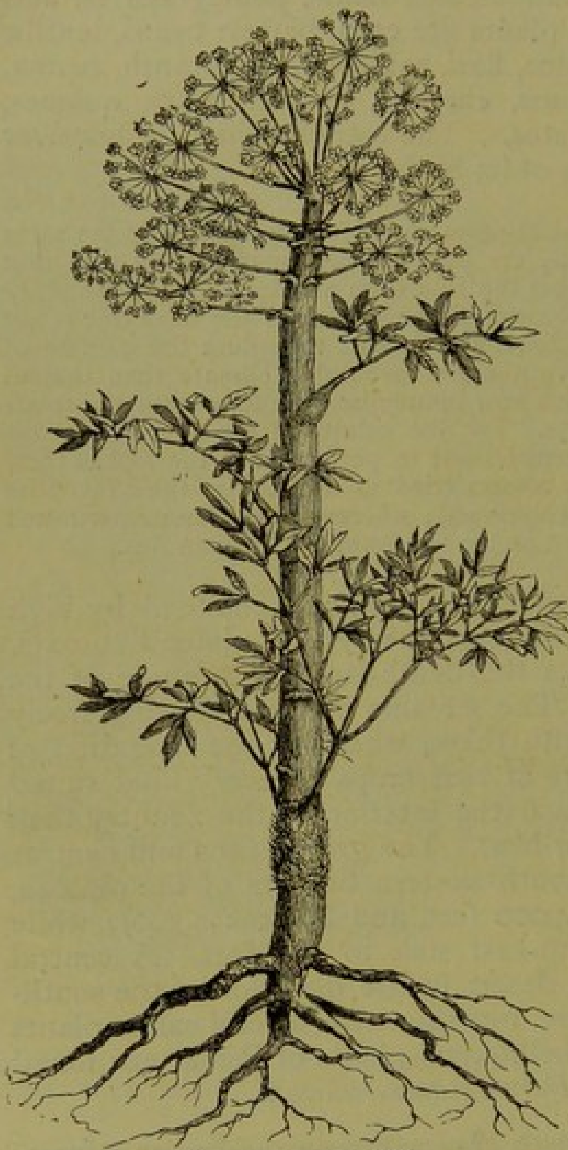
The land between the Euphrates and the Syrian heights along the coast is said to be very fruitful. Cotton plantations, rice fields, pomegranates, and sugar-cane are often seen. Other useful plants are corn, barley, beans, lentils, onions, melons, gourds, cucumbers, tobacco, flax, safflower, tragacanth, henna, liquorice, pistachio, mulberry, figs, plums, cherries, apples, pears, quinces, almonds, chestnuts, nuts, olives, and dates. The ostrich, which is however becoming scarce, is the most remarkable of its birds.

It is a singular fact that the olive and the date-palm exclude each other from the same soil. The olive grows to about 34° N. lat., while the date is only found beyond that limit There are certainly a few date-palms in Mosul, but the fruit does not ripen. This boundary line of growth is not thought to depend upon climatic influences; since the olive tree is not excluded even from the oases of the eastern Sahara, and is able to endure the climate of Bagdad; and the dates of Valencia hardly have a more favourable climate than that of Mosul. It may be that the date does not flourish here simply because its nature and treatment are not so well understood by the natives. For the culture of the olive was learnt of old by the Kurds from Syria, and has developed itself to perfection at the foot of their mountains. The Arabs, on the contrary, have always tried to acclimatize their favourite tree, the date-palm, in every country they have conquered; wherever the climate permitted its growth, in Spain as in Mesopotamia, and even on the shores of the Caspian Sea.

Persia, a high table-land sloping toward the east, and enclosed by high mountain chains, presents every characteristic of the typical plateau climate. Its strangely blended scenery comprises the death-stricken solitude of the desert and the rich culture of the oasis. The streams of water flowing freely from the encircling mountains, bring with them, wherever the irrigation of the land is not neglected, the possibility of rich crops of every kind suited to the climate; but before they can reach the interior of the country they dwindle and run dry in the fierce summer heat. The great towns and centres of agriculture lie near the northern and south-western borders of the plateau, on a high level above the sea (Teheran 4,000 feet, and Schiraz 4,300); while the deserts in the centre and the south-east sink to 500 feet. A central mountain chain, which runs through the desert in the direction of the south-east, is skirted by a highland steppe, where, together with several saline plants and thorn bushes, the characteristic umbelliferous plants of Persia are found in abundance, especially assafœtida and *Dorema ammoniacum.*

There are many species of these plants which grow wild upon the Persian steppes; but the best known, namely, the medicinal herb, *Scorodosmo fœtidum*, and the *Dorema ammoniacum*, are cultivated as articles of commerce. The resinous, milky juice is obtained from the former herb by cutting the root; but it flows naturally from the stem of the ammoniacum, or is drawn out by the sting of an insect.

Although snow falls occasionally in every part of Persia, the climate has neither the severity of the Armenian winter nor the sultry heat of Babylon, and yet it may be justly called extreme, especially in the north. The air is very dry, but the winter brings incessant rain for a short time. In Shiraz, the rainy season lasts from the middle of January to the middle of March; in other places from December to April. In Shiraz, February is the month of flowers, and all travellers agree in singing the praises of the Persian spring. Who has not heard of the vine gardens of Shiraz, of its Cyprus groves, and its Eden-like gardens of roses and lilies? And yet the enthusiasm of a Hafiz and a Sadi is only intelligible to those who know the country well; for men are grateful for the blessings of nature in proportion to the sparing measure in which they are dealt out to them. The heights are treeless, and the desert covers nearly the third part of the whole country. The salt desert, which separates the plateaus of Teheran and Khorasan, is destitute of every kind of organic life, and contains only four oases. A river-shaped salt lake lies through its deepest depressions. The lake is four miles wide, and its waters are covered by a crust of salt nearly twenty inches thick. Only two of the oases contain springs of sweet water. The traveller Bunge, who journeyed for three days and three nights with his camels through the desert of Karman, although he was familiar with the desert of Gobi, was astonished at the vast extent of barrenness in the Persian waste, and at the sudden contrast presented by the fertile oasis of Chabbis, with its wealth of palms and oranges.



SCORODOSMA FŒTIDUM.

We see at once, from the climatic characteristics of the neighbouring countries, that agriculture is only possible where there is a well-regulated system of artificial irrigation, but wherever this exists it brings forth the most satisfactory results. Heavy crops of beans, wheat, maize, and rice, vegetables of almost every kind, tobacco, wine, fruit, opium, indigo, and sesam, here and there dates, cotton, and assafœtida reward the care of the agriculturist. But not unfrequently drought will deprive the soil of all moisture; channels and even rivers run dry; famine scourges the unhappy country, and literally decimates its inhabitants, as was the case about 1870.

Long-haired goats, sheep, camels, asses, and horses are bred principally in the neighbourhood of the steppes, and find good pasture in the spring. The Persian lion, with its mane of black and brown hair, the striped hyena, bear, wolf, jackal, wild ass, and porcupine, represent the mammalia. Countless numbers of aquatic birds are found everywhere, especially in Seistan. Snakes, locusts, scorpions, and vermin of every kind infest the country, which is notorious for its mosquitoes, and for a terrible white fly which swarms to such an extent in the moist, hot margins of the marshes, that it puts an end to all attempts at buffalo rearing, and clears the farms of horses and cows, the unfortunate animals falling victims to the myriads of stings of the venomous little pest. There are few fish to be found; an English angler caught at Hamen a few barbel; the sea contains the valuable pearl shell (*avicula Meleagrina*).

The characteristic plants of the flora of Afghanistan are the tragacanth shrubs, prickly statices (sea-pinks), mugwort, wormwood, labiatæ, bulbous plants, cruciferæ, borage, and unbelliferous plants. Thorny species, hairy and aromatic plants, are very numerous, and a shrub-like growth seems a distinguishing characteristic of the country. The soil is never bare; heights and plains alike are clothed with low shrubs, many of which, especially the widespread wormwood varieties and the umbelliferous plants, are distinguished by their strong spicy fragrance, and the essence they contain is said to impart a peculiar aromatic flavour to the flesh of the goats and sheep which feed upon them. When the June sun brings in the dry season, the vegetation begins to look withered and scorched; but in spring the general tone of the landscape is a dark olive green, which is picturesquely relieved by the bright emerald green of the valleys, kept fresh and cool by the numerous streams of water which flow through them. But in the stony districts, of which the traveller sees only too many, the aspect of the scenery is far less inviting; the ground brings forth nothing but prickly shrubs with scarcely any leaves, and even these apologies for vegetation are in some places few and far between. The Hindoo-Koosh, which separates the high table-land from the valleys of Turkestan, is wooded along the crest and eastern slope with the same kinds of trees as are found upon the Himalaya; but the lower part and western side of the chain is without trees.

Maize and rice are much cultivated; the latter is found even near Cabul at 6,000 feet above the sea level. Wheat and barley are said to thrive as high as 9,840 feet. In the highland valleys, the date-palm is found at 4,600 feet above the sea, accompanied in the desert of Beloochistan by the dwarf palm, (*Chamærops*). Besides the palm we find the following fruit trees: peaches, apricots, almonds, figs, pomegranates, apples, pears, and grapes. The special production of the country is the zinzey, or *Elæagnus orientalis* (a jujube-like fruit, often forming part of a Persian desert), and a theophrasta (*Edgemarthia buxifolia*). At Cabul, where the nights are frosty till late in the spring, the summer fruits can only be put in in May, and they ripen in August and September. More remarkable still is the cultivation of maize and rice under these circumstances; we must either assume that the climate exerts a wonderful accelerating influence upon the phases of development, or that the cereals belong to a separate species, requiring a much shorter time than usual for their growth. The latter supposition is said to be true of the rice grown in China, and the maize in North America.

The wild animals of Afghanistan are the jackal, fox, wolf, and hyena; the shores of the rivers are frequented by different species of water-fowl, cranes, and pelicans; the thickets of the low-lying woods afford shelter to wild boars, hares, and partridges.

Our circular tour through Western Asia has now brought us back to our starting-point, the country of Thibet.

It is usual to include Arabia among the countries of Asia; but if the flora of a place is to be taken as the test of its alliance with other lands, we shall find ourselves obliged to assign Arabia to Africa. The spot at which the flora of the steppes meets that of the Mediterranean district is situated in the desert of Judah, a few miles to the south of Hebron. But although the vegetation of the great African desert is found south of this limit, and although at least one-third of Arabia is true desert land, it would be premature to look upon it as forming part of Sahara; for it possesses this great advantage over the latter place, namely, that not only are its coasts encircled by mountain chains which, at least in the east and south-west, are wide and fertile, but also that in the interior of the country is found grand mountain scenery like the districts of Nedjed and Shamma, which, owing to the winter rainfall, have become centres of prosperity and civilization. Palgrave, the first European who visited Riadh, the capital of the Wahabee empire, found it equal by its government and social polity to any province of Islam. It is true that the district to the north of Shamma is often called the desert of Nefud, but the title is unmerited, for its wandering Bedouins find during the winter rainfall within its borders the richest pasture land. Not until the country south of the tropics is reached, does the traveller enter the great sandy waste of Roba-el-Khâli, or Dehna, which extends to the southern line of mountains. Entering this desert from the south coast near Hadramaut, the scene unfolds itself in all the desolation of the typical wilderness—a boundless sandy plain, with an endless succession of undulating hills and valleys like the waves of a sandy sea. No trace of vegetation, not even of the lowest kind, no cry of any bird breaks the death-like silence which broods over the grave of the Sabæan host. The desert of Tehâma is a long stretch of barren land lying along the coast between the Red Sea and the chain of mountains. It is from sixteen to eighty miles in width; a desolate place, where the coast streams are dried in their channels, and the sun's heat, intensified by the bare soil and naked rock, allows no plant to grow. Not a drop of the rain which falls heavily upon the neighbouring mountains reaches this shore, for the masses of water rising from the sea are condensed by the mountain peaks, and cannot form themselves into rain clouds over the scorching coast. When, after an eight days' journey, the traveller rides through this barren waste, and suddenly sees before him the city of Medina lying in a luxuriant framework of fair gardens and well-tilled fields, he understands how the words of the Mohammedan liturgy express the feelings of every Mussulman: "And when the pilgrim's gaze falls upon Medina, then let him raise his voice and bless the prophet, using his humblest and most heartfelt benedictions." Aden, with its well-known climatic peculiarities, belongs to this district of the Tehâma.

The flora of central Arabia is rich in aromatic and resinous plants; the stems of the trees are often covered with gums and resinous juices. But this is nearly all we know of it at present.

The coasts, on the other hand, possess an entirely different kind of vegetation. Yemen in the south-west, Hadramaut in the south, and Oman in the east, have an independent flora of their own, composed of balsamic plants. This part of the country must be included in the Soudan district, and forms a transition vegetation passing over to the Indian flora. It is the home of the khât plant (*Catha edulis*), the buds of which are said to surpass tea as a stimulant. Hither it would not be difficult to transplant the coffee tree from its native soil in Africa. Aden is the chief town for this valuable export; in the year 1877, about 70,000 cwt. of Mocha coffee was sent out, and the trade was taken out of the hands of its rival stations. The forests and woods are formed of acacias, and have many forms of vegetation in common with Sennar, besides mimosas, sycamores, thorn bushes, and the leafless leptodenia. The succulent plants are represented by the aloe, the juice of which is named after the Arabian peninsula Socotra. Along the coast of

Hadramaut, a liliaceous tree, the dracæna, is frequently seen more than eighteen feet high. On the mountain slopes of Yemen, thickets composed entirely of tree junipers are met with. One of the most remarkable plants is the dogbane (*Adenium obesum*), with a fleshy, globular stem, and leafless branches, having at their extremity a showy cluster of oleander blossoms.

Special mention must be made of the medicinal plants. Foremost among these ranks the aloe. The juice extracted from the leaves of the *Aloë socotrina* is well known by the name of bitter aloes. The hardened sap of the balsamic plants (*Balsamodendron Ehrenbergianum* and *B. myrrha*) is known as the myrrh of commerce. *Balsamodendron Gileadense* and *B. opobalsamum* furnish us with balm of Gilead. The Arabian tree yielding frankincense is not yet known, although Arabia was of old time the home and cradle of this fragrant plant, and even now a large quantity of incense is brought from Yemen. Some botanists think that frankincense is obtained from the *Libanus thurifera*. The illustration on the next page represents the East Indian incense tree, the *Boswellia serrata*, beside a spray of myrrh. Among the plants not strictly medicinal, the coffee plant (*Coffea arabica*) is the most important.

ALOE (*Aloe socotrina*).

Although the coffee tree received its name "Arabica" from no less distinguished authority than that of Linnæus, its home is in the Abyssinian district of Caffa, whence its name is probably derived, in Enearea (between lat. 3° and 6° N.), and in the Soudan, where it forms extensive woods; but Yemen, in Arabia Felix, is the oldest home of the valuable plant. Left to itself, it grows to the height of from thirty to forty feet; but it is generally cultivated as a shrub, five or six feet high, to strengthen the plant, and make the gathering easier. Glossy evergreen leaves characterize the coffee tree. Its period of bloom lasts for nearly eight months, since the fresh shoots bear blossoms at once. When seen at its best, the plant is very beautiful: a snowy shower of blossom covers the dark shining leaves, through which twinkle numerous bright red berries. The latter turn violet as they ripen, and contain a white soft pith and two of the precious berries, sometimes round, sometimes egg-shaped, and either grey, yellow, or green in colour. The coffee trees are planted in regular rows. The young tree begins to bear fruit in its second year, and its yield increases every season up to the fourth or fifth year, after which time the crops gradually diminish. It loves a good deep soil, containing a large admixture of lime. Besides this principal produce we must mention the date-palm, oil-giving sesamum, millet, corn, rice, beans, lentils, tobacco, gum tree, cocoanut tree, manna (*Tamaris mannifera*), saffron, castor-oil plant, colocynth, melons, cucumbers, and truffles. Of less value are cotton, indigo, and sugar-cane.

The date-palm (*Phœnix dactylifera*) is often found to be the only tree cultivated and wild, not only in Arabia, but throughout the whole of northern Africa and the country of the Euphrates to the valley of the Indus. A line drawn from Cape Blanco to Cape Gardafui marks its southern limit in Africa; but there are many places besides where it will thrive as a cultivated tree. Even in Europe, in the southern parts of Spain, there exists a noble forest of fine date-palms, relics of the past Moorish civilization, and the tree has been transplanted to some parts of America with success. Its true home, however, is that part of the tropic zone where there is no rainfall, and where its roots are fed by the ground-water lying in the sand; since the hardness of the leaves and the thickness of their outer skin enable the tree to resist the heat of the sun. The palms can only thrive in the plains. In Syria they are found inland as far as the base of Lebanon; but they never grow on the heights, and are rarely found

MYRRH (*Balsamodendron myrrha*). FRANKINCENSE (*Boswellia serrata*).

above 2,000 to 3,300 feet above the sea. On Mount Sinai they are said to flourish as high up as 1,638 feet above the sea; but beyond this they degenerate. Along their southern boundary they seem to prefer the coasts, and are found in great abundance upon the island of Socotra. Magnificent date forests are found throughout the delta of the Euphrates and the Tigris. In the marshy depressions of the soil the stems of the wild palms take root; they do not grow here, as elsewhere, to a height of sixty feet, but form a dense undergrowth with their roots and offshoots. The fruit of the date-palm of Bagdad is still fine and pleasant flavoured. The traveller, descending the mountains of Kurdistan towards Mesopotamia, meets with the first date-palm near Altyn Kopru (35° 40′ N. lat.), and its northern limit extends eastward from that place and parallel to the mountain chain which is hostile to its growth. But still farther eastward, where the coast is visited by the south-west monsoons, the conditions necessary to its healthy growth are lacking, and therefore it is only found in British India along the upper course of the Indus, and on the south-western slopes of Cashmere.

It may be truly said of the date-palm, that no other plant has played such a part in the world's religion, in history, or in poetry. It ranks in this respect before the Egyptian lotus, the Celtic mistletoe, the lily of France, the genista (broom) of the Northmen, or the rose, thistle, and shamrock, of our own country. The writer of the Canticles borrows from its height and graceful beauty the imagery in which he depicts the royal maiden of whom he sings; and when the noble hero of the Grecian epic approaches the king's daughter Nausicaa with suppliant words, he says—

"For never saw I yet one like to thee,
 Or man or woman; and I gaze with
  joy.
 So once in Delos have mine eyes
  beheld,
 Beside Apollo's altar, a fair palm
 Whose slender, graceful stem enthralled my sight;
 For the earth holds not such another
  growth."

Coffee Tree (*Coffea arabica*).

The palm is "the queen of the oasis, whose foot is bathed in water, and her head uplifted to the fire of heaven." No storm breaks or uproots her; no sunbeam penetrates through the sheltering roof of its feathery, rustling leaves, often more than three yards in length. Sheltering the spring of water, and protecting the growth of vegetables and low shrubs at her feet, she is the creator, ornament, protectress, and wealth of the oasis. The traveller looks with joy on the distant vision of her crown of leaves as they rise above the horizon of the desert; they are the sure sign of inhabited homesteads and a welcome resting place. The pleasant fruit, in shape and size like a plum, hangs down in rich clusters, and in many places, especially in Arabia, its sweet, pleasant-tasted fruit forms the daily bread of the inhabitants, and one of their most valuable articles of commerce. A single date tree bears yearly from five to six hundredweight. The fastidious European owns the delicacy of its flavour, although it is very rare that good specimens of the fruit are sold in Europe. But the tree has not always been what it has now become. The plains of the lower Euphrates and of the Tigris were the paradise where men cultivated and improved the life-giving tree, and whence it spread to other countries. It is a remarkable fact in the history of civilization, only to be paralleled with the other fact that the dromedary, "the ship of the desert," was not known in Africa until the third century of the Christian era; and yet the dromedary seems created especially for the

Libyan desert, and by its means the inaccessible region has been thrown open to men of other races and other religions. The camel and the date-palm, two blessings of creation, closely connected in the necessities of their existence, and apparently an integral part of desert life and scenery, do not even belong originally to desert lands. They are the product and growth of the inhabitants of the desert, who tamed the one, and developed the luscious honey-sweet fruit of the other, which made this part of the globe habitable. The palm in its present state of perfection makes life only too easy for its lord and master, giving him almost all he needs without any labour; and thus adding a link to his gloomy, indolent fatalism, and to the dignified repose with which he veils the hot passions slumbering below his assumed calm. We need not specify in greater detail the manifold uses of the date-palm; we content ourselves with referring, after Strabo and Plutarch, to the Persian or Babylonian hymn in which the praises of the date-palm are sung, and three hundred ways in which it may be used are fully set forth.

First amongst the animals of Arabia ranks the *Horse*.

The Arab breed of horses is still considered to be the best. Careful breeding and training, perfected by the traditions of thousands of years, have gradually developed a perfection of form and other valuable qualities. The Arab seeks in his horse the union of the following points: well-proportioned build, short, mobile ears, strong but delicate bones, a fleshless face, nostrils wide as a lion's jaws, dark, full, lovely prominent eyes, with the expression of a lovely woman, an arched and slender neck, broad chest, and broad croup, narrow back, rounded hind quarters, very long true ribs to shelter the heart and lungs, very short false ribs, slender girth, legs swift as the ostrich, muscles strong as the camel, a black, self-coloured hoof, a fine thin mane, a soft thick tail, tapering toward the point. Such are the points on which the Arab relies in proof of the breeding of his horse, which must resemble at once the greyhound, the camel, and the dove. The mare must have the courage and broad forehead of the wild boar, the grace and eye and mouth of the gazelle, the gaiety and wisdom of the antelope, the wiry build and speed of the ostrich, with the viper's shortness of tail.

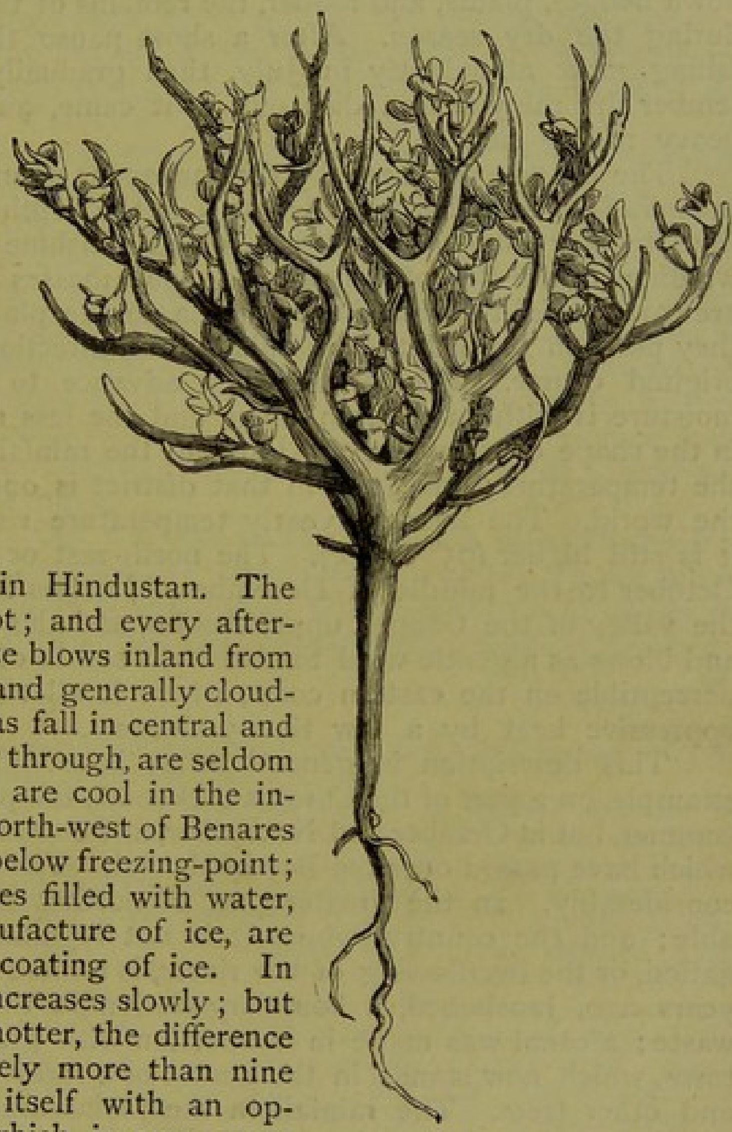
The dromedary and ass, valuable as they are in the desert, are thrown into the shade by this favourite of the Arab. There is little else to say of other animals; the wandering tribes are rich in herds of cattle, and flocks of sheep and goats. Among wild animals we find apes of several kinds, lions, hyenas, jackals, gazelles, with many birds of prey. The insect pests of the land include locusts, stinging flies, etc. Snakes, lizards, and scorpions are rare.

The peninsula of Sinai is a rocky waste. Little can be said of its organic life; the flora is represented by the rose of Jericho (*Anastatica hierochuntica*), and the manna plant (*Parmelia esculenta*).

The rose of Jericho, famed in many a legendary story, is a little plant which, at the time of ripening, rolls up its sprays into a ball, and unfolds them when dipped in water. Pious pilgrims, who brought back the plant from their wanderings in the Holy Land, related wonderful stories of its powers of blossoming afresh on Christmas Eve, a miracle accomplished by the aid of water. This blossoming is a purely mechanical process, somewhat akin to the expanding of a sponge in water. The immersion in water does not renew the actual growth of the plant, although it does affect the fruit, which only yield their seed in water. If the plant is carried by the wind from its native soil, and borne across wide deserts, it often happens to reach some moist places where it unfolds and lets fall its seeds, thus creating fresh life in the desert. The cruciferous plant (*Parmelia esculenta*), or manna, is originally fastened to the soil; but when torn up and carried away by storms, it falls down in a shower of manna in small fragments about the size of peas. It is often carried in this way for great distances. Many think this plant is the same as the manna of the Bible. Wherever it falls it grows again, with the aid of rain, and is a welcome plant in the desert. So simple are the methods by which the life of plants is sustained even in the most unfavourable circumstances. What could be more thrifty than to deposit the vegetable matter inside the little rose of Jericho, that it may gather up the dew of the desert, or to tear and break up the dry, parched lichen, and scatter it in light, easily carried particles, where it may multiply and find life possible?

Southern Asia.

India and the island world of Southern Asia present such marked contrasts with respect to their organic life, that they may well be classed under many separate divisions. In the first place, the boundaries of the vegetable and zoological regions very seldom coincide. For while New Guinea and numerous islands of the Pacific Ocean must be considered as belonging to the monsoon district of Australia, the province of Sindh, and the peninsula of Gujerat, and the whole of Hindustan must be excluded, and either classed as a separate region of vegetation, or included in the desert region of Africa. But, from a zoological point of view, the boundary line between the Asiatic and Australian fauna must be drawn between Borneo and Celebes; and some of the Asiatic islands must be assigned to Australia.



Rose of Jericho (*Anastatica hierochuntica*). Natural size.

The months of January, February, and the first half of March bring with them fine and pleasant weather in Hindustan. The days are not oppressively hot; and every afternoon a cool refreshing breeze blows inland from the sea. The sky is clear, and generally cloudless; showers of rain, such as fall in central and northern Europe all the year through, are seldom if ever known. The nights are cool in the interior of the land. To the north-west of Benares the temperature sinks even below freezing-point; and the tanks, like flat dishes filled with water, and intended for the manufacture of ice, are found covered with a thin coating of ice. In April the heat of the days increases slowly; but the nights become rapidly hotter, the difference of temperature being scarcely more than nine degrees. May announces itself with an oppressive increase of heat, which is even more perceptible on the coast, where the air is saturated with water, than in the interior of the land. The thermometer scarcely falls three and a half degrees all through the night. The earth has lost every vestige of green; and all living creatures seem lifeless until the rainy season sets in. The sky is covered with those clouds to which the pious Hindu ascribes a divine origin; the south-west monsoon bursts over the land, and alters the aspect of the whole country. The monsoon or season winds are divided into south-westerly and north-easterly; blowing for six months in one direction, and six months in the other. In southern India the south-west monsoon begins in June; higher up the country it does not occur so soon. Dark cloud masses rise in the south-west; for a few days the weather is only threatening; at length the evening sky becomes black, and the rain breaks forth. Thunder-storms, such as rarely visit our temperate zones, accompany the outbreak of the rain. This state of things lasts for a few days; then the sky clears, the air, purified from dust, becomes transparent, the whole earth is rapidly covered with luxuriant green, countless insects and small quadrupeds come forth from the lurking places in which they have contrived to drag on a wretched existence, the swollen rivers carry down hedges, plants, and fodder, the remains of the crops sown in their beds during the dry season. After a short pause the rain breaks out again, falling most abundantly in July, then gradually decreasing, until in September the rainy season dies out as it came, amid thunder, lightning, and heavy rolling clouds.

The change produced by the monsoons upon all kinds of vegetable life in India is as startlingly sudden as if in the depth of our European winter we were to wake up to the blossoms and sunshine of the spring. Along the windings of the Bay of Bengal, the cloud masses of the south-west monsoon are carried right across the peninsula to the plains of the Ganges; whence they pass on toward the Himalaya, in a direction exactly opposite to their original course. The farther they advance to the north-west, the more moisture is withdrawn from them, and the less remains for them to scatter in the shape of rain. In the Punjaub the rainfall is not sufficient to depress the temperature; and June in that district is one of the hottest months in the world. The average yearly temperature rises to 9·14°; and in Sindh it is still higher (95° to 96°). The north-east or winter monsoon blows from October to the middle of December. It rises in the plains of the Punjaub, the valley of the Ganges, upper Assam, and the table-lands of central India, and blows as a gentle wind toward both coasts of the peninsula. It is most perceptible on the eastern coast, where it alleviates, in the hot season, the oppressive heat by a few timely showers.

This description in general terms is modified by local influences; for example, on a part of the Coromandel coast, the periodic rainfall occurs not in summer, but in October and November, and comes with north-easterly currents which have passed over the Bay of Bengal. The amount of the rainfall varies considerably. In the greater part of north-western India it is inconsiderable; and the country, where it is not regularly watered by artificial irrigation, or the overflowing of the rivers, is a mere desert. For example, forty years ago, Jacobebed, a boundary station in the north-west, was a barren waste; a canal was made in connection with the Indus, and carried to the town, which now stands in the centre of a forest of acacias (*Acacia arabica*) and other trees. The rainfall in the plains amounts to eighty-four inches, that is, to about five or six times as much as that of central Germany; but in the hills it rises to twenty, or even to thirty-four feet. The latter height is reached at Chesrapoongee, in the Khasia mountains, north-east of Calcutta, and 3,440 feet above the level of the sea. The long-continued drought of the Indian climate is most perceptible in its effects on the high-water mark of the rivers. During the summer, immense quantities of water are rolled seaward through the great streams; but in the winter the amount is relatively insignificant. The basin of the Indus is estimated as nearly five times that of the Ganges, as about seven and a half times that of the Rhine; and yet, in the dry season, these mighty rivers are no deeper than the Rhine at its average height; while many streams, whose basins are almost equal to that of the Rhine, can easily be crossed on horseback in the dry season.

As a necessary result of these peculiarities, East India possesses every kind of climate possible within the region of the tropics, and along its northern frontier it even approaches nearly to the climate of the temperate zones. Not to speak of the fact that upon the peaks of the Suliman chain, to the west of the Indus, and on those of the north-western Himalayas, to a height of 3,100 feet above the level of the sea, snow falls instead of rain, regular night frosts occur in Sindh up to 28° N. lat., and in the Satpoora mountains to the south of the Nerbudda river, as far as lat. 23°, hoarfrost and ice are met with at the height of 1,968 to 3,100 feet above the level of the sea.

The climate of Further India is too little known to be described in detail. Along the island chain from Java to Timor, we find a transition climate from the moist tropic lands to the dry trades of the Australian continent. The principal trees of Timor are Australian in type (eucalyptus and acacia), and although these forms are not immigrant, but native plants, their arrangement in light copses exactly corresponds with the character of the vegetation of New Holland. This phenomenon is the more remarkable, because farther eastward the flora of the monsoon district is entirely cut off from the Australian flora by the Torres Straits, although the distance of New Guinea from the opposite continent is not nearly so great as that of the island of Timor, and only amounts to one hundred miles.

It follows from all this, that the flora of the monsoon district possesses no unity, but only presents the prevailing characteristics of the tropics, but it should be added that the climate of Hindustan, and as a matter of course its vegetation also, is widely different from that of many other tropical countries, owing to its long dry season.

Such a marked likeness runs through all tropical scenery, that it may be well to give a brief general description before going further into detail.

Scientific naturalists (Darwin writes) describe the scenery of tropical countries by naming a number of different objects, and mentioning also a few characteristic features of each. It is possible that this method may present certain definite ideas to a learned observer, but what unscientific reader can picture to himself, from the sight of a plant dried in a herbarium, the aspect of the living plant growing in its native soil? And who is able, by looking at a few exotics in a conservatory, to imagine some of them enlarged to the proportion of forest trees, and others entangled in the bewildering growth of the jungle? Who by examining a collection of choice butterflies or cicalas neatly arranged in a case, can associate these lifeless specimens with the indolent flight or the shrill incessant music of the living insects, the faithful companions of the silent burning noontide of the tropics? When the sun is at its fiercest, the dense splendid foliage of many a plant veils the earth in deepest shadow, while the upper branches, bathed in the most brilliant light, shine in intensest green. In the temperate zone the case is altogether different; the vegetation is neither so dark nor so bright, and therefore the rays of the setting sun, tinged with crimson or pale gold, lend to these climates their special beauty. Walking quietly along the shadowy path in Bahia (Brazil), and gazing in admiration upon every changing prospect, words fail the naturalist to describe the ideas aroused by the beauty before him. Adjective after adjective is tried, and found too weak to bring before the mind of those who have not visited the tropics the feeling of enchantment produced by the scene. The whole country is a vast, wild, luxuriant, ill-kept conservatory, created by nature, but taken possession of by man, who has covered it with bright houses and artistically laid-out gardens. Great is the longing implanted in every lover of nature to gaze upon the scenery of another planet; and yet for every European, at a distance of only a few degrees of latitude, the wonders of another world are unfolded in the tropics. "I paused often in my wanderings," says Darwin, "to gaze upon the loveliness round me, striving to imprint upon my memory a lasting picture of the scene which I know must fade too soon. The shapes of the orange tree, the cocoa palm, the mango tree, the tree fern, and the banana, will doubtless remain distinct, but the thousand beauties which blend all these into a perfect whole must grow faint and dim. And yet, like a fairy tale heard in childhood, they will leave behind a picture of vague, but none the less beautiful, images."

One reason which explains the difficulty of describing tropical forest scenery is that the woods are not, like those of our temperate zones, composed principally of trees of the same kind. The tropical forest contains within its vast extent specimens of the most widely different classes; even the distinguishing trees are represented in every possible variety of family. The same thing is true of the countless climbing plants, and the many growths which cling to the trunks of the trees, and form a shadowy roof of leaves overhead, where the manifold forms of the tropical flora avail themselves of every inch of space to develope their luxuriant growth. The savannahs cannot, it is true, be compared with the forests as to their variety of productions, but in almost all tropical lands they follow the same law of formation. We must not, however, pass from these general outlines to definite descriptions, lest we should overstep the bounds of strict accuracy; for tropical scenery has never yet been described in sufficient detail to admit of anything more than a rough sketch. The practical descriptions of the American primeval forests have often excited admiration, while they left the reader unsatisfied; and such a reader travelling in the East Indies would certainly find his high expectations disappointed. And yet the vegetable forms of the Indian archipelago are so far from being eclipsed by those of South America, where the luxuriance of vegetable life seems to have put forth all its energy, that many a picture of the landscape scenery of Brazil may, according to Zollinger, pass for types of the vegetation of Java. But it is the especial characteristic of tropical Asia, that, as it embraces every gradation of tropical climate, the most luxuriant flora passes gradually to the poverty and barrenness of the desert. In the face of this fact, it seems less remarkable that civilization has made here far greater changes in the original conditions of the original vegetable life than it has done in any other continent of the tropics. For, as a matter of fact, the population of India far outnumbers that of any other tropical country. Even the tillage of the soil has in many parts of Hindustan almost entirely effaced the tropical characteristics of vegetation. Java, on the other hand, is as densely populated, and yet the native flora still prevails in face of advancing civilization.

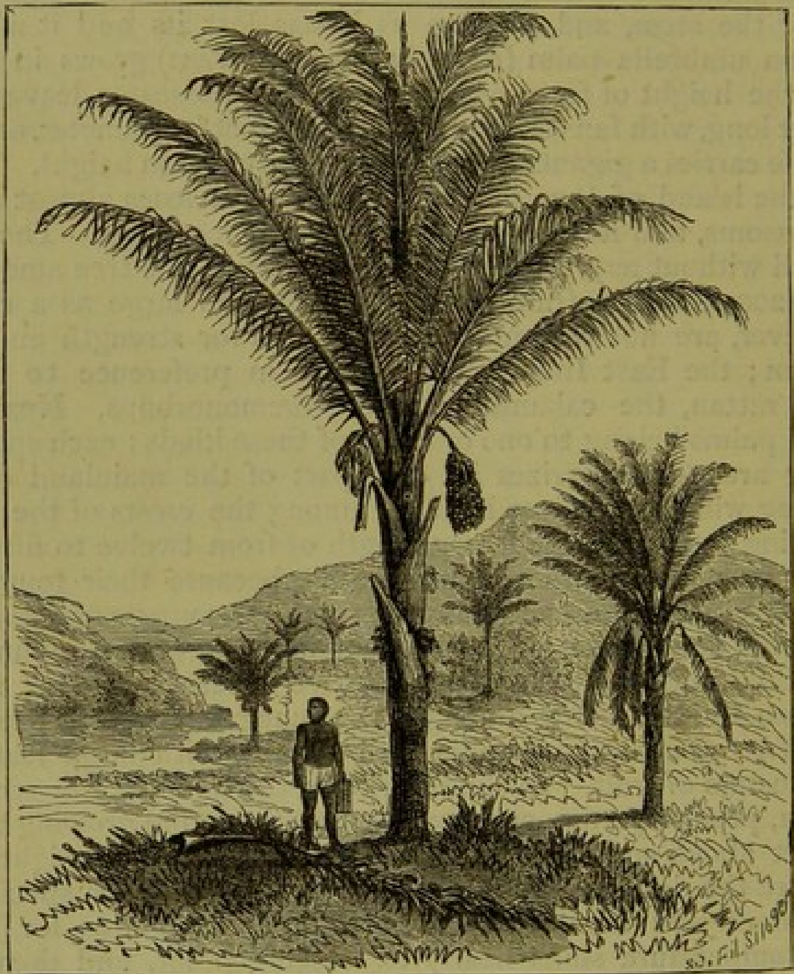
In the country of the monsoons, the palms, the aristocracy of vegetable life, attain to their widest development. Of the nearly 960 known varieties, a third part belong to this region, and especially in the district from the islands of Java to New Guniea. It is hardly possible to imagine a more favourable climate than that which prevails in Sumatra. The average monthly temperature remains almost uniform between 78·8° and 80·6°, and the average daily variation seldom amounts to more than 7°; the atmospheric moisture oscillates between 78 and 86 per cent., never sinking below 50 per cent.; the rainfall of the driest month reaches ten inches in height, and that of the wettest month twenty-four inches. In Sumatra alone there are forty-seven species, about half of which are peculiar to the island. For while the African palms have an extensive territory, the rule holds good here as in America, that most of the species are only found in a very limited area, and it has been supposed, with every shew of probability, that the few widely spread species owe their dispersion to culture alone.

In western Hindustan the palm flora is confined to very few varieties.

It becomes richer along the moist southern slopes of the Himalaya. Thus in the valley opening upon the Bay of Bengal (valleys of Sikkim), there are already fifteen kinds. Wherever the moisture decreases, a few new kinds appear, to replace others which disappear, as, for instance, the *Phœnix sil-vestris;* and at last upon the Himalayan chain the palm flora dies out with the dwarf palm (*Chamærops Martiana*). Hardly one of these palms is found in Ceylon, which has sixteen different kinds of its own. In the *Sunda Islands* there are many forests of palms, principally composed of the useful cocoa, areca, and fan (*Borassus*) varieties. Other kinds grow singly, or side by side with kindred forms, and among these we must mention the famous umbrella palm (*Corypha*). This species is distinguished above all others by its immense leaves. It puts forth large club-shaped blossoms at the crest of the stem, and as soon as it has lost its bud it withers away. The common umbrella palm (*Corypha umbraculifera*) grows in Ceylon and Madras to the height of forty-five to sixty feet, possesses leaves more than eighteen feet long, with fans from nine to twelve feet in diameter, and to the end of its long life carries a gigantic inflorescence sixty feet in height. The *Corypha gebanga* of the island of Java is rather smaller; it loses almost all its leaves when it blossoms, and its inflorescence is twelve feet high. The majority of blossoms fall without any fruit, and yet the fruit of one tree amounted to the number of 200,000; the fruit, when ripe, being as large as a cherry. The palms, however, are not the most distinguished for strength and luxuriance of vegetation; the East Indian would point in preference to the climbing palms, the rattan, the calamus, and the dæmonorhops. Nearly half the East Indian palms belong to one or other of these kinds; each species, limited to a narrow area, characterizes its own part of the mainland or its special island. They wind themselves high up among the crests of the trees, sometimes attaining to the extraordinary length of from twelve to fifteen hundred feet. They make the jungles impenetrable, because their tough stems are armed with strong prickles, and hang down their scourges of swaying tendrils set with thorns and hooks. The different districts of the mountain regions are also distinguished by their representative species of palm; for instance, in Java, close by the shore, amongst the mangrove forests, grow numerous bushes of *Nipa fruticans*, a wonderful low palm with large feathery leaves and thick clusters of fruit. In the interior of the country the principal kinds are wallichia, ptychosperma, and areca, which are found growing to the height of 2,050 feet above sea level. In the dense woods, at a height of 2,050 to 4,620 feet, are the different kinds of climbing palms; other species of *rattan*, *calamus*, and *caryota* are found up to 7,700 feet high, as far as countries where the temperature sinks nearly to freezing point, and then at last the noble palm flora is forced to yield the place to low trees and bushes of bilberry and rhododendron. The forest palms of the Indian archipelago which are most deserving of attention are the cocoa palm (*Cocos nucifera*), sugar palm, (*Arenga saccharifera* and *Arenga Rumphii*), sago palm (*sagus*), and lastly the betel nut or *Catechu palm* (*Areca catechu*). More imposing than these in their effect upon the landscape, both by their beauty of form and their isolated position, are the solitary growing species of *areca* and *Piranga*, the *Caryota ureno*, the feathery fan palm (*Licuala*), and last, but not least, the giant *Livistona*, whose crown sometimes rises high above the crest of all the surrounding trees, and is visible on the horizon at a distance of many miles. The cone-bearing palm (*Cycas circinalis*) is nearly allied to the dwarf palm, but is easily recognized by the greater stiffness of its narrow feathery leaves. It is found generally along the coasts of equatorial lands, growing but slowly, yet reaching at times to a considerable height.

We shall speak more at length of the various uses for which palms are employed. For the present we need only mention that the cocoa and Palmyra palms rank first among the palm trees of India for the valuable food they yield; and the sago palm is the most useful of the palms of the Moluccas and the Sunda Islands.

The importance of this great vegetable tribe well deserves a lengthened notice. Palms appear at times in the form of low shrub-like plants, at other times as tall, magnificent forest trees, now scattered through the forests of the tropics, and hidden under its dense foliage, now towering high above its tallest trees; in one place grouped in light copse-like glades, in



SUGAR PALM (*Arenga saccharifera*).

another standing proudly alone; sometimes, though very rarely, side by side, forming a dense forest. They grow in such different lands, and under such different conditions, that it is well nigh impossible to draw a hard and fast line defining the necessities of their existence. The only general rule which seems to admit of no more exceptions than are sufficient to prove it, is that they cannot bear frost, and that they need a large supply of water. We may also add that most of the palm tribe require an uninterrupted water supply, and do not thrive in any country where the period of vegetation is interrupted by a rainless winter, and yet the date-palm and the flourishing condition of the doom palm of Egypt are sufficient instances to shew that even this rule is not infallible. The forests of the province of Minas Geraez, in Brazil, dry and leafless in the winter-time, also are indebted for their only verdure to the scattered trees of the *Cocos coronata* and the parasites living upon the forest stems. In this instance the palms must be fed by subterranean watercourses. It is also found that palms seek the plains, and avoid the higher mountain slopes, where the air is too cold for them; but the famous wax palm was seen by Humboldt to rear its proud crown of leaves upon the Andes of Quindiu, at the height of from 5,676 to 9,270 feet above the level of the sea; nearly 6,500 feet higher than any other kind of palm, and only 2,600 feet below the snow line. The *Euterpe andicola* also grows in Bolivia, on the summit of the Cordilleras of Cochamba, along the steepest rocky slopes, among countless little shrubs, forming the boundary line of tree growth, and situated very little below the snow line. The stem of this palm measures still more than sixteen feet in height; and Hooker says that palms and bamboos are there found up to the height of 9,000 feet. These examples, however, must be looked upon as exceptions; and, apart from them, only those districts which possess a uniformly high temperature and an uninterrupted water supply can be considered favourable to the growth and development of the species. There are only two areas of any considerable extent in which both these conditions are complied with; namely, Further India, with the large islands situated near the equator, and the river basin of the Amazon. In these districts grow the greatest numbers of different varieties, and of specimens in each particular kind. Up to the present date the following kinds are known :—

200	varieties	in the Sunda Islands, the Moluccas, and New Guinea.
180	"	" basin of the River Amazon.
90	"	" district of tropical America on this side of the equator.
90	"	" district of Brazil.
80	"	" district of Mexico.
70	"	" district of the tropical Andes.
70	"	in Further India.
50	"	in Hindustan.
40	"	in the West Indies.
19	"	on the northern coast of Australia.
17	"	" western coast of tropical Africa.
11	"	" eastern coast of tropical Africa.
11	"	in southern China.
10	"	in Madagascar.
6	"	on the east coast of Australia.
6	"	in the northern Pampas.
6	"	in Florida.
3	"	in the prairies.
3	"	in Sahara, Arabia, the steppes as far as the Indus.
2	"	in South Africa.
2	"	in Chili.
1	"	in Europe.

Out of these 400 varieties of the eastern and 562 of the western hemisphere only a small proportion of the palms belonging to any of the districts mentioned above belong to the same kind as those of the adjoining countries; while isolated species are found upon several of the islands.

Next to the palms, the bamboo tribe claims precedence among the plants of India, both by its variety of form and its great numbers. According to Zollinger's table of the different Javanese species, certain kinds which grow to the height of more than ninety feet, individual examples 130 feet high have been measured, but the average height varies between twenty and fifty feet. The prickly bamboo does not grow so high, but twines closely round the nearest stem, and forms an impenetrable jungle or bush. The thickness of the stem varies between about twelve inches and the tenth of an inch. The colour of the leaves shades from bright green to a pale yellow tint. The climbing lianas, for instance, the *Dinochloa*, which resembles the rotang palm in its circular formation, hangs down its graceful branches tipped with a feathery tuft of leaves. The slenderer forms put out fresh growth at the summit of the stem, which hardens by the amount of silica which it contains, and is covered with joints from which short branches tipped with leaves are put forth all the way down the stem. When they are joined together, they shoot upward like a gigantic cane bush, and at last bend down on all sides in gently curving arches to the ground. Their social life, the close disposition of the stems which sway with a soft rustling murmur at every breath of wind, the dead leaves which cover every inch of the soil, exclude all other kinds of vegetation from the interior of a bamboo jungle. When the water supply is abundant, the growth of the bamboo increases with almost miraculous speed, so that in a few days the stem gains several feet, and lengthens as it were visibly before the eye; it is nevertheless able to support the interruption caused by long seasons of drought, and is therefore equally at home in the swampy forest as in the parched savannahs. The largest bamboo indigenous to Siam develops its sheaf of stem of eighty-two to ninety-eight feet high in the space of three or four months, and then begins to fade in the dry season, and sinks to the ground. A tropical climate is not an absolute necessity for the growth of the bamboo, some of which are seen in Sikkim at a height reaching to the limit of tree growth.

The numberless ways in which the bamboo enters into the national life of the countries where it is found has attracted the attention of every traveller. The longer he sojourns in eastern lands, the greater is his astonishment at the myriad purposes to which certain plants are applied by the Orientals. In the first rank among these necessaries of eastern life come the cocoa palm and the bamboo. The Javanese builds his house of bamboo ; every article of household furniture is made of the same material ; he lights a fire of bamboo, and over it he cooks his rice in a bamboo dish, which is charred, but not destroyed, in the process. Very possibly the dish may contain, instead of rice, some young shoots of the bamboo, which form a tender and succulent vegetable. Sometimes no other material is seen in a whole village ; the fairy-like palisading which encloses it, and the gates themselves, are all made of bamboo. The prickly bamboo, a species which grows to the height of thirty-nine feet, in thick bush branches covered with formidable thorns, forms a rampart hardly to be broken through, even by the aid of artillery ; so that the Dutch, taught by their experience in Sumatra, always plant it round their fortresses. The sportsman and the soldier use it for lances, arrows, and a blow-pipe, by means of which poisoned arrows are shot. It is constantly employed to form bridges, and it provides the fisherman with incomparable rafts, masts, and creels. In China, nearly all the paper is manufactured from bamboo, even paper used in Europe for art printing. The canes in use among us are bamboos, while the cane used for chairs, etc. is obtained from palms, natives of the East Indies, especially the *Calamus rotang* and *Calamus verus*. To add one more use to which the inexhaustible bamboo may be put, we may add that a wedge-shaped piece of the cane cut the cross way of the stem, so that the sharp edge is formed of the outer silicious stratum, makes a knife good enough to be even used in surgical operations.

GROUP OF BAMBOO CANES.

We see, then, from the foregoing particulars, that it is not possible to sketch in a few words the characteristics of this region.

The part of the Himalayan territory not yet brought under the absolute dominion of England is but little known as regards its different forms of organic life, and we must content ourselves with saying that Cashmere is admitted to be one of the most picturesque spots on the earth. Peaks white with eternal snows rise above the richly wooded valleys, and countless streams wind through the flowery plains. Star-like lotus flowers rest on the surface of the waters, which afford a resting place and food to numerous aquatic birds. Among the most characteristic vegetal productions is the *Trapa bispinosa* or Singhara nut, which furnishes the people of the valley with a nutritious food. Wilson reports that Lake Wollar supplies about 1,200,000 cwt. of these valuable nuts.

Descending from the snow-covered peaks of the Himalayas to the valleys at their base, we meet with the outposts of organic life, mosses and lichens, just as is the case in our European mountains. Next to the mosses come rich mountain pastures of manifold character—partly Siberian, partly European. Gentian, anemones, aconite, larkspur, saxifrage, primulas, speedwell, wormwood, sorrel, baldrian, lousewort, geraniums, poppies, tragacanth, and other European kinds, are mingled with purely Asiatic types, such as spikenard (*Nardostachys*), panax, and rhubarb. The latter (*Rheum nobile*) is famed as the most beautiful plant of Sikkim. Then comes the region of Alpine plants: glorious rhododendrons, with immense clusters of blossom, realise the ideal attempted by their magnificent European sisters. Among them blooms the silver rhododendron of Sikkim (*Rhododendron argenteum*), a tree forty feet high, with leaves twelve or fifteen inches long; and what a wealth of colour! what endless variety of species! In Laghep alone Hooker collected twenty-four different kinds, whose splendid blooms seemed to exhaust half of the spectrum of colour, ranging from white through gold-colour, vermilion, rose, carmine, and purple. The smaller kinds exhale fragrance from their leaves, and the two sides of the leaf present a beautiful contrast between the dark, glossy green of the upper and the silvery or brown shade of the under side, which is covered with a silky down. Low willows aud dwarf junipers grow with the rhododendrons to their highest boundary.

We enter next a pine wood, containing, it may be, twenty different kinds of conifers. Its most beautiful ornament is the Deodara cedar (*Cedrus Deodara*). It is found growing between the north-east of Afghanistan and Nepaul, at the height of from 7,500 to 12,400 feet above the level of the sea, and for the first 1,500 feet the long-speared conifer (*Pinus longifolia*) accompanies it. Higher up, the latter is replaced by the silver fir (*abies pindrow*), and the fir (*Picea Khutrow* or *Picea morinda*). But the Deodara cedar is found in the greatest degree of perfection upon the mountains of the interior, where it is removed from the influence of the plains, and veiled in snow for nearly half the year. There is an extensive forest in Kamaoon, where the cedars range from twenty to twenty-five feet in diameter. Along the northern slopes of the Boorum and Roopin passes there are specimens of from 150 to 200 feet high, and not less than twenty-eight feet in diameter. Gradually, other kinds of trees begin to appear among the cedars: Hippophaë, poplars, and mulberry trees; then follows a woodland region, of which the trees are the same as those found in the temperate zones, and correspond in their different species to our European growths: Birch, willows, alder, poplar, oak, elm, maple, horse-chestnut, pear, cherry, and mulberry trees. The undergrowth is composed of alder bushes, mountain ash, barberry, a kind of cherry, bladder nut (*staphylea*), rose, hazel, wild vine, honeysuckle, and blackberry brambles. Not until these forms disappear does the true tropical wood begin with its cassia, laurel, myrtle, orange, acacias, tree-like mallows (*Hibiscus*), begonias, bamboo, figs, breadfruit, and bananas; lastly, tree fern and palms, the region of spicy plants; but there are also other aspects of plant scenery;

for instance, the mountains of the east and west possess widely different characteristics. In Simla the mountain-sides are rocky, and, as a rule, treeless, open, and rich in grass. The crests alone are crowned with woodland, which continues down the slopes of the northern side. The low projecting hills are covered with shrub growth, indicating the dryness of the climate; then follows a more open region, partly wooded. Examples are found, also, of high mountains, covered from base to summit with a mixture of herbaceous plants and rock, and other heights which belong to the temperate zone, the true forest region not beginning until the height of 6,560 feet above the level of the sea is attained. Even here, among the clouds, the forests are light and open, consisting of conifers, oaks, and rhododendrons.

The transition from the mountains to the plain is effected by means of the Terai, flat terrace formations from 260 to 1,150 feet above the sea; stretches of land where the mountain streams lose much of the violence of their descent, and deposit a light soil of loose earth and rock. In many places these terraces only form a narrow belt; but in others, and especially in Nepaul, they are forty-five, and sometimes sixty miles wide. Upon them grows the valuable saul and sissoo trees (*Shorea* and *Dalbergia sissoo*), towering above the bamboo, magnolia, and dwarf palm. These plantations are separated by jungles from the open country. From the swampy soil of the jungle rise dense sedgy grasses and savannah reeds, forming a thicket where the tiger finds shelter, and growing high enough to hide the elephant. The height of the grass is favoured by the rise and fall of the waters, which overflow and diminish according to the season of the year. Among this scenery the epiphytes and lianas attain to their highest development. When compared with the luxuriant growth of these parasites, the independent growths appear relatively poor and monotonous. A single stem, with its adornment of lianas, resembles a conservatory filled with the most widely differing forms. It is disputed whether the high growth of these parasites is caused by their desire to escape from the swampy soil, or is merely an effect of the energy called forth by the exuberance of life developed by the warm, moist climate. It is, in any case, a result of that impulse which causes every plant to seek the light, which is necessary for the development of its nutritious juices. The lianas attain this object by their immense length. Clinging like ivy to the stem, twining round it like the hop, seizing hold of every branch like the vine, they add to these well-known forms of the temperate zones the tropical characteristics of mutual intertwining and the leaflessness of the lower part, reaching out, twisting round each other, growing upward and downward in corkscrew-like progress, plaited together, hiding their foliage and blossoms amongst those of other plants. Another peculiarity is their growing from tree to tree, catching at any support which offers itself, encircling it in slanting spirals, or falling loose from the branch. Even such jutting fragments of rock as may be found among the trees are closely embraced by the lianas, since the latter draw their nourishment from the ground, and not from the objects to which they cling. The typical characteristics of the Asiatic jungle are presented by the rattan palms and freycinetia, and the climbing bamboos; while the smileacæ (*sarsaparillas*), which abound in all tropical lands, well deserve a place at their side. Many families of lianas are found among the dicotyledones, such as the husked or leguminous, wolf's milk, vine worts (*cissus*), and figs; while others, although not so rich in different varieties, contain many characteristic growths, as the *sapindaceæ*, *melastomaceæ*, and pepper worts. Still more numerous are those families which, without turning to wood, climb and intertwine, though not at so great a height, as convolvuli, gourds, milkwort (*asclepiadeæ*) and yarn (*dioscorea*). Solitary kinds of liana growth are laurels, gentian, and ferns.

Plants which do not grow in the soil, but upon other plants, without, however, twining round them, are called air-plants or *Epiphytes*. They choose as their support the trunk or crest of the tree, and the more foothold they can gain, the richer is their development. Certain forms of these plants are parasitic; that is, they plunge their roots into the tree to which they cling, and feed upon its juices. How then are the true epiphytes nourished? Many of them send out aërial roots which seek the earth, plant themselves, and draw their food from the soil. Others content themselves with the scanty fare of inorganic substances brought by the wind to the projecting parts of the trunk and branches, and which the decaying bark, mosses, and falling leaves fertilize with soil, while the rain keeps them moist. Just as the pine thrives in a little loose earth scattered over the bare rock, so in the jungle we find giant fern fronds, large-leaved shrubs, and bushes with dense foliage enthroned upon supporting trees, which can do little or nothing more than find them room to live in. Little as this is, it seems amply sufficient, and it is evident that light and air are more important to the clinging plant than is the support to which it is attached; for the column-shaped trunk of the *Altingia excelsa, e.g.*, with their smooth bark and leafy crown of air plants, remain free from epiphytes, and even repel most kinds of lianas by their great circumference. Among the epiphytes we find shrubs resembling oleander, rhododendron, nightshade, and figs, mingling with more delicate growths; together with the large-leaved rosettes of the orontiads (*Pothos*) and aromatic canes; but all these forms are surpassed in richness of variety by the countless tribe of ferns, and leaves free play to the inexhaustible wealth of atmospheric orchids. The joints or knots of these orchids attach themselves as readily to the rock as to the trunks of trees, and the same rhododendrons (*Rh. javanicum*), which grow upon trees in the darkness of the woods, take root just as freely in the soil, and form an undergrowth.

Even the aspect of the jungle is not the same everywhere. To the west of Nepaul, where the rainy season is shorter, and the winter cold increases, the jungle becomes gradually more monotonous. The palm lianas cease beyond the valley of the Ganges. Melastomaceous plants and atmospheric orchids, so common in the eastern Himalayas, disappear from the landscape in Simla. The western limit of the epiphytic aroids, aromatic spice plants, balanophoreæ, and begonias, is found at Sutlej. Other Malayan forms are restricted to the eastern Himalayas, and only extend to the limits of Sikkim and Nepaul, such as the gum tree (*Ficus elastica*) of Assam, the cycads (joint firs), and gnetum (*Cycas pectinata, Gnetum scandens*). If we follow the Himalayan chain to Mount Khasia, which forms the connecting link between Himalaya and the Malayan peninsula, and then continue along the western coast of Malay as far as Java, we find a succession of uniform climates. Jungles extend over this whole distance, which comprises nearly thirty-six degrees of latitude, and the vegetation of the southern slopes of the Himalaya partakes more nearly of the character of Java than of that of Hindustan; for there the most luxuriant jungle lies side by side with barren, desolate tracts which appear all the more poverty-stricken from their close proximity to the rich growth of a moist climate. As the greatest part of Hindustan is composed of desert land, the contrast of the peninsula to the unchanging green of the wood-grown archipelago is very striking to the geographer, and would have led to the separation of the two floras under different divisions, if they were not so closely connected by Further India and the humid regions of the Himalaya, the coast of Malabar and of Ceylon. In most places the traveller, whose imagination has been fired by the popular ideas of tropical scenery, finds nothing but disappointed expectations, and must not expect to be consoled except by the short-lived luxuriance of the rainy season, and of those places which are watered by means of artificial irrigation.

Not until the year 1864 were the forests of British India placed under the control of the government, who speedily checked the wholesale and reckless cutting down of timber, which was threatening many valuable species of forest trees with extinction. In the province of Bengal, the wooded districts of Sikkim and Bootan consist chiefly of saul trees (*Shorea robusta*), the hard wood of which is admirably adapted to the laying down of railway lines. The high slopes of Darjeeling, lying more than 5,900 feet above the level of the sea, are now being planted with many forest trees belonging to the temperate and sub-tropical regions; among others, the mahogany tree, which is a native of Central America.

As a rule, conifers are most abundant in the north-western provinces, which, next to Burmah, are the best wooded districts in the whole country. *Pinus longifolia* is the representative tree of this class, and covers in Kumaon and Gurhwal nearly 400,000 acres of ground, while the forests of Goruckpore consist principally of saul trees. The teak tree (*Tectonia grandis*), distinguished by its large, wide leaves, more than twelve inches in diameter, attains its northern limit in Bundelkund. An attempt has been made to introduce this tree into the Punjaub, but without success; the dry climate does not suit it, and its growth is stunted. These trees, when they lose their leaves in winter, resemble our trees overgrown with mistletoe, only that the epiphytes and ferns flourish on a much larger scale, and clothe the bare branches with perpetual green, while the loranthus species unfold at the same time their coloured blossoms.

The saul woods are seen again in Oudh; but the growth of the trees is threatened by a number of destructive lianas, among which are *Bauhinia vahlii*, *Argyreia speciosa*, and several other climbing plants. Large sums of money have been expended on the destruction of these hurtful creepers. Besides the saul forests, Oudh possesses valuable plantations of sissoo (*Dalbergia sisso*), feathery-leaved toon (*Cedrela toona*), and ebony (*Diospyrus ebenum*).

Saul trees are also found in abundance in the Punjaub, but they reach their northern limit in this province, on the banks of the Beas river. The woods yield now more than 1,000,000 cwt. of wood for the heating of the locomotives. Large woods of *Cedrus deodara* are also found in considerable numbers; and in order to turn to account the large barren plains of this province, the authorities determined, about 1868, to plant some Australian trees, with good results. Among the kinds thus introduced are eucalyptus, acacia, and casuarina.

In the central provinces the government is anxious to develop the planting of teak woods and saul trees. Large tracts of land have been planted with these trees. In the alder plantations, sissoo, *Terminalia tomentosa*, and the *Pterocarpus marsupium* are found.

The above remarks hold also good with reference to Hyderabad, whose vegetation shews a great similarity to the central provinces.

Mysore has been long famous for its teak and sandal-wood. The latter covers very large tracts of land. The whole country, indeed, is so well wooded that some of the forests had to be cleared to make room for coffee plantations. Valuable timber is also obtained from Tectonia, and from large woods of *Dalbergia latifolia*, and *Calophyllum elatum*.

The large and magnificent forests of Burmah are composed of teak, and are still more increased by the constant planting of young trees. To give an example of the energy and activity with which the work is carried on, it is enough to mention that in the years 1864-5, more than sixty-four square miles of land were mapped out and traced upon the charts, and the planting of them is carried on systematically. Burmah possesses also valuable woods of ironwood (*Inga xylocarpa*), which yields excellent materials for railway sleepers.

In Madras, where the regular supervision of forests is of much longer standing, teak is the principal tree, as, indeed, it is in all the southern provinces; and here, too, the greatest efforts are being made to replace the woods in their former condition of productiveness. Thus there are large new plantations in Malabar and Canara; while in the Nilgherries, eucalyptus and acacia; in Cudapah and Sigur, red sandal-wood; and in Shevaroys, toon are cultivated on a large scale. In the years 1866-67, for instance, 120,000 seedlings of teak were planted in Malabar.

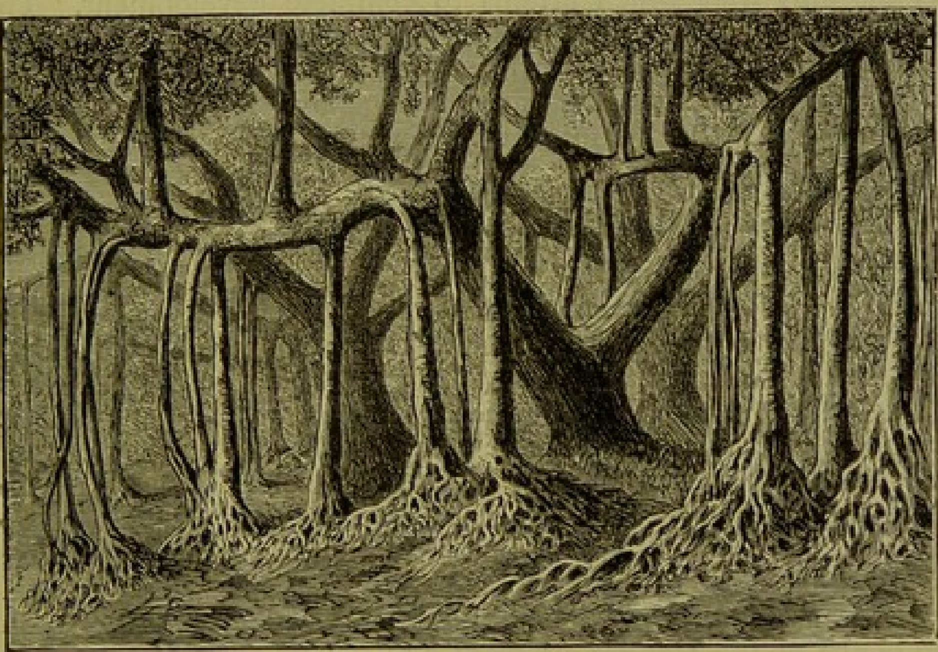
These energetic measures are necessitated by the need of firewood for the railways. Until the present time the enormous amount of fuel thus consumed was obtained from the jungles; but many of these are already so exhausted, that their cultivation is utterly inadequate to meet the demand.

In Bombay the same need is felt, and efforts are being made to meet it in the same manner.

In the province of Sindh, *Acacia arabica* thrives freely, and its wood is highly esteemed for building purposes. One of the trees most frequently found in the dry regions is the *Butea frondosa*, with its large three-parted leaf and tall stem. Even when it has lost all its leaves, it is an ornament to the landscape, being covered with splendid bright-coloured yellow blossoms nearly two inches long.

The dryness of the climate affects the forests in another and perhaps more disastrous manner. Every year, toward the beginning of April or May, there is an outbreak of fire in almost all the woods except those composed of evergreens. They arise in many different ways, sometimes lighted by peasants or shepherds in the hope of getting fresh grass on the burnt soil, and sometimes caused by mere carelessness. The forests are seldom very dense, so that the fire does not rise far above the ground, but incalculable mischief is done to the young growth and the stems of the older trees. It is very difficult to guard against the recurrence of these devastating fires, but progress is being made, and whenever the forests have been protected from conflagration, the growth of bamboo and timber trees has been most luxuriant, and the clearings are rapidly becoming covered with fresh growth.

Among the other most interesting plants of this part of Asia are the banyan, mangrove, and lotus. The banyan (*Ficus indica*) sends out aerial roots from its branches, which grow



Banyan Tree (*Ficus indica*).

down vertically, and take root in the soil, from which they provide the parent stem with nourishment, and also form a new crown of their own; crown after crown expands and spreads abroad over the stems of the first growth and the aerial roots. A large forest in the archipelago was well described by Reinhardt: he tells us that all the trees there spring from one stem (*Ficus benjamina*), and all were still connected one with the other. The mangroves are distinguished from the banyans, because the aerial roots are not formed from the branches themselves, but from the fruits growing out of them; and the new species gradually separate themselves from the parent stem. Skirting all the tropical coasts, where the soil is formed of clayey slime, and protected from the surf, these trees uplift their short stems and glossy leafy crowns high above the surface of the waters which reflect them. During the ebb of the waters the roots are laid bare; like wide-spreading, branching runners, they penetrate deep below the slimy soil, and at their meeting point above the mud or water they carry the stem which floats loose in the air. In a soft soil, covered twice a day by the salt waves of the sea, all germination of seed or stability of the young plant is out of the question; the foliage also is not intended to be washed by the water, so that the downward-hanging fruit makes itself free from the parent stem as soon as a new tree has shot forth from them, which, like a bark steadied by many anchors, is upheld and rendered capable of resisting the force and movement of the waves.

The nymphæ or lotus flowers, kindred blooms to our water lilies, take root also under water, and rank as one of the distinguishing plants of Indian scenery, not so much on account of their number and beauty, as of their influence upon the religious beliefs of the natives. Here, indeed, is the land and home of the mysterious lotus blossom, which, from the perfection of its organism, its petals, stamina, and stem, stands in the Eastern imagination as the symbol of that creative power which acts upon the inorganic creation to form, renew, develop, and bring it to perfection.

The changes effected by culture of the soil upon the climate and scenery of India are less apparent than those which are produced in the temperate zones; as, for instance, in Germany, where agriculture exerts such a wonderful influence upon the climate. In the tropics, where the palm, the bread-fruit, and the bananas yield such inexhaustible supplies of nourishment almost without the aid of cultivation, more thought is bestowed upon the culture of trees. The case is widely different in the open scenery of the Deccan, where the inhabitants are principally devoted to agriculture. Not even fruit trees thrive in this part of the country; perhaps the mango (*Mangifera indica*) is the only fruit which attains to complete development. The heat of the spring tide, which might serve to ripen the fruit, is not the season in which wood plants develop; this occurs in the rainy season, which is the time for tree growth. Even the eastern Himalaya is not well adapted for the cultivation of fruit, for the mists of the winter are hostile to the blossoms. In the western valleys, where the rain is often interrupted by intervals of sunshine, European fruits of tolerable flavour are obtained; but the vine is not met with until the climatic limit of the monsoon rains is reached in the Sutlej valley of Kunawur.

Rice is the most important vegetable growth of India. The natural explanation of its universal culture is found in the inundations of large tracts of land by the alternate rise and fall of the great rivers, and by the advantage taken of the yearly rainy season for the irrigation of the young plants. In many places the autumn crops are succeeded by the cultivation of winter fruits, which are gathered in before the hot days of the spring. At this time the scenery presents something of a European aspect, with its fields of oats, beans, flax, and potatoes. Wheat is grown in the Punjaub, and eastward as far as Benares; cotton fields are seen upon the table-land of the Deccan and the west coast of Guzerat; while poppy and indigo are largely cultivated along the banks of the Ganges. Sesam and ginger must also be mentioned among the objects of culture, and yams are found in the south of Hindustan.

Besides the annual growths, the appearance of the landscape owes much to the trees which are cultivated for their valuable produce. Thus Java has its characteristic coffee plantations, Ceylon its cinnamon, the Moluccas their muscat and spices. In the South Sea Islands the bread-fruit and the cocoa-palm are the representative trees; and in Malabar and Siam pepper is principally cultivated. The fruit trees have still to be mentioned; some of the noblest fruits of the tropics are natural products of these climates; for instance, the citron worts are supposed to have originally come from the Maylayan peninsula.

More than 160 varieties of citron worts are recognised by botanists; but as all these species can be referred to a few kinds, it will only be necessary to mention one or two. The *Citrus medica*, familiar to the Romans before the birth of our Lord, still grows wild in the forests of northern India. It is now widely spread through Brazil, the Argentine Republic, Congo, and the south of Europe. The lemon of commerce is perhaps only one variety. This valuable fruit, with its smooth thin rind, was brought over during the Crusades, and is largely cultivated in the south of Europe. It is still found growing wild in the forests of northern

India. Of the two kinds of oranges, the bitter variety is probably the original fruit from which the sweet orange was developed, and yet the former no longer grows wild, while the latter is found in the north of Bengal, in Burmah, in the south of China, and Cochin China. Hence its German name of *China apple*. In the ninth century, the bitter (Seville) orange was brought to Arabia, in 1002 it was already cultivated in Sicily; while the sweet orange is said to have been first brought to Europe in the year 1548. The *Citrus decumana* is a native of China, but is now plentiful in the Indian archipelago. Its heavy fruits, often weighing from ten to twelve pounds, are articles of commerce, the thick rind being prepared with sugar, and sold as candied lemon-peel. There are numerous other varieties, such as the Bergamotte, which yields a fragrant oil; the lime, a descendant of citrons and oranges; the Japanese citrons, and others too numerous to be mentioned.

In the next rank to the citrons come the *Jambosæ*, an order which includes many different varieties, some of them resembling our apples and pears. The most important of them, *Jambosa vulgaris*, or rose apple, is a plant resembling the myrtle, which bears a delicious gold-coloured fruit possessing the fragrance of the rose. Growing wild in the Malayan peninsula, and found also in Penang, it has spread to Malabar and Ceylon, Arabia, Egypt, Sierra Leone, probably even to Brazil; although it may be that the jambosa of the latter country belongs to another species, namely, *J. macrophylla*. This variety bears a red fruit, while some of its kindred are gay with dark-red, white, or wax-coloured fruits. Other fruit trees, also called *jambosæ* by the natives, belong to totally different species, some of them being foreign importations. Thus they have the Dutch plant (*Djambu molanda*), and the *Persea gratissima* of South America, and the guava imported from the West Indies. Even the *Anona squamosa* (custard apple) is a native of South America, coming originally from the plain at the mouth of the Amazon; but it has spread so rapidly, and grows in such abundance in China, Hindustan, Cochin China, and the Philippines, that it is now considered to belong to those places. In appearance it resembles our hanging elm, with narrow pointed leaves covered with short hairs on both sides. After a short period of sleep, when the tree is leafless, the blooming time begins, and lasts through the whole summer. In the green flowers, which are of moderate size, and very fragrant, many germs are found united upon a single base, as in the ranunculus; they grow together, and form a cone-shaped fruit, whose regularity of form depends upon the more or less perfect fructification. A ripe well-formed fruit weighs about 1¼ lb., and shews the limits of each germ as a flat but clearly defined scale. The first flowers produce the first fruits; the tree yields for several months, but the later fruits are smaller than the earlier ones. The custard apple should be eaten immediately after it has ripened; even on the second day it loses much of its flavour, and after two days it is uneatable. But when eaten just at the right moment, it is one of the most delicious fruits of the tropics. The soft milk-white pulp, in which the shining black seeds lie scattered, has a flavour in which sour and sweet are so happily blended, that it far surpasses the most finely flavoured creams of our cuisine.

The mango tree (*Mangifera indica*) is a genuine child of the monsoon region; it has been exchanged for the anona of America, and is now cultivated in Brazil with great success. It is a rather large tree, resembling our apple tree; the blossom is pink and white, and the fruit is something like a peach in size, shape, and colour. Its seed is enclosed in a woody kernel. It deserves well the high estimation in which it is held, although the flavour of certain kinds is a little like turpentine. The kernel, when roasted, tastes like a chestnut.

The mangosteen (*Garcinia mangostana*), a tree about thirty-three feet in height, which is said to surpass all others in the flavour of its orange-like fruit, is less frequent; it possesses a combination of the best qualities of the peach and the pineapple. Its nearest of kin, the East Indian *Garcinia cylanica*, *G. cornea*, *G. cochinchinensis*, and *G. cambogia*, contain juices which are distilled from incisions in the bark; and when dried, are exported for painting purposes, under the name of gamboge. They are, however, very poisonous.

One of the oldest cultivated plants, and greatest blessings of the tropics, is the banana (*Musa*).

BANANA (*Musa paradisaica*).

Although the different kinds of banana (*M. sapientum*, *M. paradisaica*, *M. canedichi*, etc.) differ slightly in the size and shape of their stem and leaf, the general likeness existing between each variety is strongly marked. The young flower stalk shoots out slowly from between the sheaths, in the form of a thick cone enclosed in coloured bracts. Only the first blossoms bear ripe fruit, and in bringing them to perfection the tree seems to exhaust itself, a thing not to be wondered at when we learn that the fruit case of the *Musa sapientum* and other low-growing varieties sometimes is bent down to the ground by fruit forty pounds in weight. As the fruit ripens gradually, the yield lasts throughout the year; so that the planter, when planning out his new settlement, devotes himself first of all to the planting of this invaluable tree, because it is of itself sufficient to supply his need; consequently men have planted it in the tropics wherever there was a chance of cultivating it. The bananas ask so little care in return for their bounteous gifts, that a moist soil and sufficient warmth is all that is needed for their welfare. The varieties which bear eatable fruit never form seeds, but are propagated by means of shoots or layers. The cucumber-shaped fruits measure from about three to six inches in length, and, generally speaking, the fruit of the smaller bananas is considered to possess the richest flavour. It is eaten raw, after removing the thick outer covering of leathery rind; and tastes like a soft apple, half sweet and half sour, with an additional flavour peculiar to itself.

Other varieties of fruit, belonging more especially to Borneo, will be described at length in the chapter which treats of that country. For the present we need only mention durian, lanseh, rambutan, tree gooseberries, etc. Besides these there are the numerous members of the fig tribe, including the jujube, mulberry, vine, nut, and chestnut, all of which will be found in our notices of other lands, besides many only acclimatised in India, like the melon tree (*Carica papaya*). We must not forget to include the mulberry tree, which is so successfully cultivated, especially in Brahmapootra, that silkworm rearing is now an established branch of trade there.

The bread-fruit tree, that is, the genuine bread-fruit (*Artocarpus incisa*), with its large, deeply serrated, feathery leaves, and the non-serrated jack tree (*Artocarpus integrifolia*), are found throughout the whole extent of India.

The true bread-fruit tree measures from forty to fifty feet in height, and is probably a native of the South Sea Islands; but as at the present time it is no longer found wild in any country, it may be introduced here side by side with the jack tree, as belonging to the East Indies. The fruit of the latter tree is often twenty-five pounds in weight, and forms a nutritious article of food, the pulp and especially the seeds, which resemble chestnuts, being eaten. The true bread-fruit is cultivated especially in its varieties which make no seeds; and

Bread-fruit Tree (*Artocarpus incisa*) and Banana (*Musa paradisaica*).

the flesh of its large melon-shaped fruit, which weighs from three to four pounds, is prepared in many ways. The bread-fruit tree bears during eight or nine months of the year, and yields such an abundance of ripe fruit, that two or three trees can support a man for a whole year, and any one who plants a dozen of these trees is often in a position to leave his family better provided for, than a lifetime of hard work would have enabled him to do elsewhere.

We shall have to speak later on of the three most valuable palms of the East Indies—the cocoa, sago, and fan palms. The latter, also called the lontar, Palmyra, toddy or wine palm (*Borassus flabelliformis*) bears upon its stem, which measures from twenty-five to seventy feet, and is about twenty-four inches in diameter near the base; its leaves are fan-shaped, and more than twelve feet in length and eight feet wide, growing on stalks four feet long.

The fruit, resembling a cocoanut, grows to the size of a child's head, and forms the chief article of food for millions of Indians. Toddy, or palm wine, is also obtained from this tree.

Toddy is gained by wounding or squeezing the spathes of the female blossom, while yet upon the tree. The process is repeated for three days in succession, the flowers thus being prevented from opening; on the four following days a piece is cut off from the top of the blossom, and on the eighth day the palm wine begins to trickle out of the wound. It is a light-coloured sap with a saccharine flavour, and is drunk fresh or after fermentation, when it resembles a sweet wine. A large healthy tree yields about one pint and a quarter of the juice daily; a poorer tree yields much less, but the flow of sap lasts without interruption for five months, beginning in January, so that one tree can yield more than twenty-two gallons of the wine. The juice treated with lime is made into a kind of brown sugar, called jaggara, and this in its turn is fermented and made into an intoxicating beverage, also called palm wine.

Ginger Plant (*Zinziber officinale*).

If we turn to the consideration of agriculture, we find that our attention is claimed first by rice, corn, and cotton; for upon the successful cultivation of these plants the welfare of British India is chiefly dependent. As, however, we shall have to speak of the cotton plantations more fully under the head of American plants, we will content ourselves for the present with a short description of the rice fields.

The vast plains extending from Calcutta to the ocean, and traversed by the many mouths of the Ganges, are constantly exposed to inundations and destructive storms which render all kinds of tree growth impossible; but are admirably adapted to fertilize the soil, and prepare it for the production of heavy crops of rice. Nothing can be imagined so monotonous as the endless stretches of brilliant green, which extend to the farthest limits of the horizon, without the slightest break or the appearance of any sign of life. The rice fields are parcelled out into divisions of about two and a half acres each, and the last two or three hours of each day are devoted by the workmen to the irrigation of the fields, which is accomplished in the following manner:—A number of tanks are sunk in the earth to the depth of four to six feet below the level of the Ganges, and fed by the numerous channels led from the mouths of the river. To distribute the water of these channels over the fields a curious method is employed, which proves to be as efficacious as it is ingenious. A tree stump about fifteen feet high is planted by the side of each tank, and surmounted by a cross-beam, so as to form a rough kind of see-saw, to one end of which a copper or earthen vessel is suspended by a rope of cocoanut fibre. Two men are required to work each machine; one of them runs to and fro along the cross beam; the weight of his body alternately lowering the vessel (which generally holds about ten to twelve gallons), and raising it when full from the tank. Meanwhile the second workman gives a push to the vessel, which makes it swing backwards and forwards, and pour the water into the trenches and over the rice fields.

The ginger plantations present a singular spectacle. From a low, creeping root, the ginger of our shops, rises the ginger plant (*Zinziber officinale*), slender stems, from three to four feet high, supporting sedge-like leaves; with flower stems from eight to sixteen inches long, bearing a sheathed, oval flower, which only lasts for a few hours. Other plants of the same tribe, especially spices, are widely grown. The best known are the cardamoms—the Malabar cardamom (*Elettaria cardamomum*), with its small aromatic fruit; and the Ceylon cardamom (*Elettaria major*), said by several writers to be inferior to its kindred plants from Malabar. The two species of curcuma (*Curcuma longa* and *Curcuma zedoariæ*), or the zeodary, are also valuable medicinal roots, and successfully grown.

The poppy (*Papaver somniferum*) is a favourite garden flower, even in Europe, where it is found in all its gay varieties of colour, none, however, surpassing the original, with its pure scarlet blooms. This plant has been cultivated in India from time immemorial, for the opium it contains; but it is only within the present century that its culture has reached such great proportions. In the year 1794, the East India Company supplied the Chinese markets with 200 chests, containing a total weight of 266 cwt.; while in the year 1869, the trade had increased to such an extent that 71,000 cwt. were despatched to China; and in 1879, more than 95,000 cwt. were sent.


Poppy (*Papaver somniferum*).

Opium is prepared from the unripe fruits a few days after the shedding of the flower petals, by a slight incision of the poppy heads with a knife, and the opium appears as a milky juice, which flows from the wound. It is then dried, and the amount sent out yearly from the East Indies is nearly 100,000 cwt., bringing a clear profit of about £5,000,000.

The enervating effect of opium upon those who are accustomed to its constant use has induced many portions of the community in England to uplift their voices in protest against the Anglo-Chinese opium trade, which they consider to be as great a national disgrace as was the infamous traffic in slaves, which the English government has suppressed. But, strangely enough, the conscience of the nation which was so quick to respond to the outcry against slavery, shews itself dull and indifferent to the sin of the opium trade. In some cases newspapers are found which say that it would no longer be a philanthrophic action to limit the importation of opium from India to China, since the plant is now widely grown in China itself; and when the ambassador, Sir Rutherford Alcock, concluded a treaty with China, and raised the import duty on opium from thirty to fifty taels (about £16) for every chest weighing 133 lbs., the comments of a part of the English press were to the effect that it would be worse that unwise, it would be an unexampled blunder, to permit any increase of the Chinese import duties, without, as is easy to prove would be the case, exacting even the shadow of an equivalent. The East Indian opium trade not only throws into the treasury of British India the sum of £4,800,000 a year, and keeps up by its lucrative voyages the steam communication between the several countries of the East, but it contributes essentially towards keeping the trade of eastern Asia in the hands of the English. The cheap rate at which British capital can be made available, and the ease with which it is turned to account is probably one of the principal causes which have made Great Britain the first goods dépôt of the whole world, and one important element contributing to the same result is the advantageous rate of exchange effected by the opium trade between India and China. If this trade were summarily abolished, we should be obliged to procure £10,500,000 to pay for the tea and silk exported to us from China, and to pay for it, not as we do now in English goods, but in gold and silver, bought in America, and sent across the Pacific Ocean. An important link in the commercial connections between ourselves and the East would be broken through, and a fresh link added to the chain which would soon connect China with the United States of America. It was, however, admitted by the same newspapers, that the question of the Indian opium trade was ripe for a thorough and searching investigation, and that the direct part taken by the English government in the opium trade of Bengal was to be regretted. It is to be wished that the investigation may result in the withdrawal of English protection from this abominable trade.

PEPPER PLANT AND FRUIT CLUSTER (*Piper nigrum*).

Next to opium, the favourite stimulant of the East is *betel,* obtained from the betel palm, called also areca or catechu palm (*Areca, Catechu*).

The stem of the betel palm is from forty to fifty feet high, but only eight inches thick, and bears a crown of waving branches with long feathery leaves. The crown measures from six and a half to thirteen feet in diameter, and the leaves are from three to four feet long. From the richly scented flowers are developed the betel nuts. The fruit is about the size of a hen's egg, of a pale gold colour, containing the nut itself, which is as large as the yolk of an egg, hard and horny in substance, and marbled inside like the interior of a nutmeg. A pepper plant with a stem about as thick as a man's finger, and with veined, egg-shaped leaves, sharply pointed at the end, climbs up the stem of the palm. This is the betel pepper (*Chavica* or *Piper betel*). Both of these plants are used as ingredients in the *siri* (pinang or betel, which is for many of the Indians a necessary of life. It is prepared in the following manner :—The unripe betel nuts are cut in pieces and wrapped up in fresh leaves of the betel pepper, which have been previously spread on one side with slacked lime. Very often the siri is mixed with a little catechu or gambir, an extract obtained from the *Acacia* *catechu*, particularly *Nauclea gambir*. The betel so prepared is chewed by young and old, rich and poor, men, women, and children. It is offered to friends and visitors, and it is looked upon as a special mark of esteem or consideration when a chief removes the betel from his own mouth to present to the person whom he wishes to distinguish. The betel nut is said to have a pleasant flavour, and the leaf to be strongly aromatic. When first chewed, siri or pinang acts as a narcotic; but its effect, like that of tobacco, is weakened by use, and at last is no longer felt. It stains the saliva, the gums, and the lips a deep red, and its effect on the teeth is most deleterious. Under its influence they become first yellow, then brown, and finally black, when they fall out. In spite of this injurious effect upon the teeth, the fashion of siri-chewing seems to be too deeply rooted to be laid aside, and its advocates say that it is an admirable digestive. Other medicinal qualities are claimed for it by the Javanese, who use saliva stained with pinang for the cure of wounds and burns. They accompany this treatment with mysterious incantations, and with breathing upon the affected part, and they imagine that the combination produces admirable results. In many parts of Java, distances are reckoned by so many bites of siri, as they are in Peru by the number of bites of cocoa.

Black pepper (*Piper nigrum*) is obtained chiefly from Malabar, Ceylon, and the Sunda Islands. A climbing shrub, with stem about as thick as a finger, and measuring from twenty-two to twenty-five feet high, attaches itself indifferently to any tree, clinging to it like the vine. The oval leaves bear clusters of fruit, the berries being as large as peas, and changing from green, first to yellow, and then to a dull red. They are gathered when green, dried, and sent into the market as black pepper. White pepper is obtained from the ripe fruit, when the red shell has been removed. Although the pepper plant is now cultivated in America, particularly in Brazil, yet the greatest quantity is obtained from the East Indies, the best quality coming from Malabar.


SESAM PLANT (*Sesamum orientale*).

Sesam is highly prized as an oil-producing plant, and is cultivated like our own rapeseed. *Sesamum orientale*, or white sesam, and *S. indicum* (black sesam) both belong to the order *labiatæ*. The fresh oil is greatly valued throughout the East as an article of food; it is less liable than are many vegetable oils to become rancid. As an article of commerce, it is much used in France in the manufacture of toilet soaps. The plant has for many years been acclimatised and cultivated in America; and it was well known to the ancients, for among the Greeks, of classical ages, Sesam, a mixture of honey and the roasted seeds of the plant, were presented in Athens to wedding guests.

Among leguminous plants we must mention indigo (*Indigofera tinctoria*), a shrub growing from two to five feet high, and cultivated over large tracts of ground. The indigo so highly prized as a dye, for its deep blue, is extracted from the plant as a white, colourless sap, which only changes colour by exposure to the oxygen of the atmosphere. Nine hundredweight of the plant yield two pounds of the dye, 4,500 tons of which find their way every year to the markets of Europe.

Corchorus textilis and *Corchorus capsularis*, annual plants, belonging to the order of linden plants, grow wild throughout the East Indies, Ceylon, and China, but are cultivated for their fibre, which is sold under the name of jute. The great extent of this branch of trade may be learnt from the following statistics. In the year 1852, about 170,000 bales, of from 300 to 350 lbs. each, were exported to Great Britain; while in 1872-73 more than a million and a half were received in England.

In recent times another article of commerce has been obtained from the seas of the monsoon districts, namely, the curious algæ, which dissolve when boiled, and form a shapeless gelatinous substance, much used for cooking purposes. Such are the *Euchema spinosum* and *Euchema gelatinæ*, or *Agar-agar*. About the middle of the present century a valuable addition was made to the already long list of useful plants received from India; namely, the cinchona tree.

In the year 1852, the German naturalist, Dr. Haszkarl, received a commission from the Dutch government to travel to South America for the purpose of purchasing cinchona trees, and transplanting them to Java. After encountering indescribable difficulties, Haszkarl succeeded in 1854, in conveying 400 young trees (*Cinchona calisaya*) to Java; a consignment of seed had been sown in the preceding year, and was promising well. Unfortunately Haszkarl was not permitted to superintend the development and growth of the young plantations; for the great exertions of the journey, and the trying climate of Java, brought on a violent illness, which entirely incapacitated him from directing the experiment. The costly plants were nearly all lost through ignorance and mismanagement, the young trees being planted in the dense shadow of immense forest trees, under which they grew rapidly at first, but soon became weaker, and in many instances died. The proper method is to plant them in ground which has been newly cleared, and to leave a few shadow-giving trees among them, as is done in the coffee plantations. Now the cinchona are counted in Java by millions, and yielded in the year 1878, 44,000 lbs. of the valuable bark. Even about 1865 the cinchona tree was so completely acclimatised in India, and prospering so well, that the English government, following the example set by Holland, ordered plantations to be laid out in Sikkim, near the Himalaya, and in the Nilgherries, or the Blue Mountains, on the coast of Malabar. We learn from the report of the fifteenth year on the government plantations in Sikkim, that in the years 1876-77, 201,455 lbs. of dried red bark from the *Cinchona succirubra*, and 6,326 lbs. of the yellow and grey bark were obtained. Of the above-named kind there were 2,691,000 trees, not to speak of half a million young seedlings not yet planted out. 190,798 lbs. of the harvest were prepared, and 3,750 lbs., or nearly 2 per cent., alcaloids obtained on the spot; an inconsiderable amount, which, however, is highly remunerative, since, if we reckon the original price of each pound at 16*s*., and remember that in Germany the invaluable specific and febrifuge costs from £7 10*s*. to £10 the pound, we shall see at once that the profit repays the cost and labour. However, that may be, it is now an undisputed fact that the cultivation of the cinchona tree in Java and Hindustan enables us to be entirely independent of South America, and it is to be hoped that in time the strong competition will have the effect of lowering the price of this valuable drug. Attempts have been made, but without success, to introduce the cinchona tree in other places, especially in Algiers.

It is a singular fact that the *Cinchona calisaya*, the variety originally introduced into India, is not the one now cultivated there; and even the *Cinchona succirubra* has lost much of its old reputation. The beautiful variety of *Cinchona calisaya*, of which the seeds were collected by an English traveller in the empire of Brazil, to the south-east of Lake Titicaca, is now known as *Cinchona ledgeriana*. Principally, if not exclusively, cultivated in Java, the bark of the tree, after from six to eight years, yields from ten to twelve per cent. of quinine, a quantity far greater than any which has ever been obtained from the bark of a South American tree. There are two rival methods, each of which is supported by many cultivators; one of which consists in *mossing*, and one in *coppicing*. Mossing is stripping off vertical pieces of bark, about one or two inches wide, and then wrapping up the tree stem in moss. The bark is soon renewed, and is found to be richer than before in the precious febrifuge. Coppicing is allowing the tree to reach the age of eight years, then cutting it down about six inches above the ground, and peeling off the rind. Side shoots soon appear from the stump, which in another eight years supplies new bark. Whether coppicing or mossing is the better system is still undecided, and it will require the experience of many years to decide between the two methods.

The second plant of importance in the Indian trade, and one which is of comparatively recent introduction, is tea. The great value of this branch of trade in the countries near the southern Himalayas, and especially in Assam, where it was introduced by Lord William Bentinck in 1834, may be learnt from the fact that in the year 1876, 578,000 lbs. of tea were exported from Kumaoon, 350,000 lbs. of which were taken by merchants from Central Asia; and, according to Batten's report, the harvest of 1877 was far richer than that of any preceding year.

But what is there which is not cultivated in India? It seems as if it were hardly possible to mention any plant which it is desirable to introduce into the monsoon regions, for which a fitting place of cultivation may not be found. Among other plants acclimatised from other lands, we may mention the pineapple and the cochenille.

CEYLON.

The island of Ceylon is famed throughout the world for its fertility and the treasures of nature which it contains. Large forests, full of the most valuable trees, ebony, teak, palms, bread-fruit, tamarinds, figs, and bananas cover the interior of the country, while splendid groves of cocoa trees cover almost the whole extent of the coasts. The principal objects of culture are the coffee plant, cinnamon, cotton, and cardamoms.

Cinnamon (*Cinnamomum ceylanicum*) grows wild, but is also much cultivated in gardens. The appearance of a cinnamon garden is extremely monotonous. The bushes are planted in rows about four or five feet apart. Every bush consists of four or five plants, measuring from ten to twelve feet in height. The slender stems resemble those of our hazel-nut bushes, and are covered from top to bottom with leathery leaves about seven inches long and two wide. The leaves, when crushed, send out a fragrance resembling that of the pink. The insignificant-looking flowers are of a greenish yellow colour, and have a faint scent which is by no means agreeable; the popular legends of the rich fragrance of the cinnamon groves being only one among the many fabulous stories current respecting the wonders of Ceylon. The cinnamon gathering takes place thrice a year, in May, June, and in November, when the plants are fuller in sap, owing to the influence of the rainy season. The outer skin is then easily stripped from the wood. The best sort of cinnamon is as thin as good writing paper. It is white when gathered, and has very little scent or taste; but as it dries, the colour changes to brown, and the taste becomes very sweet and aromatic.

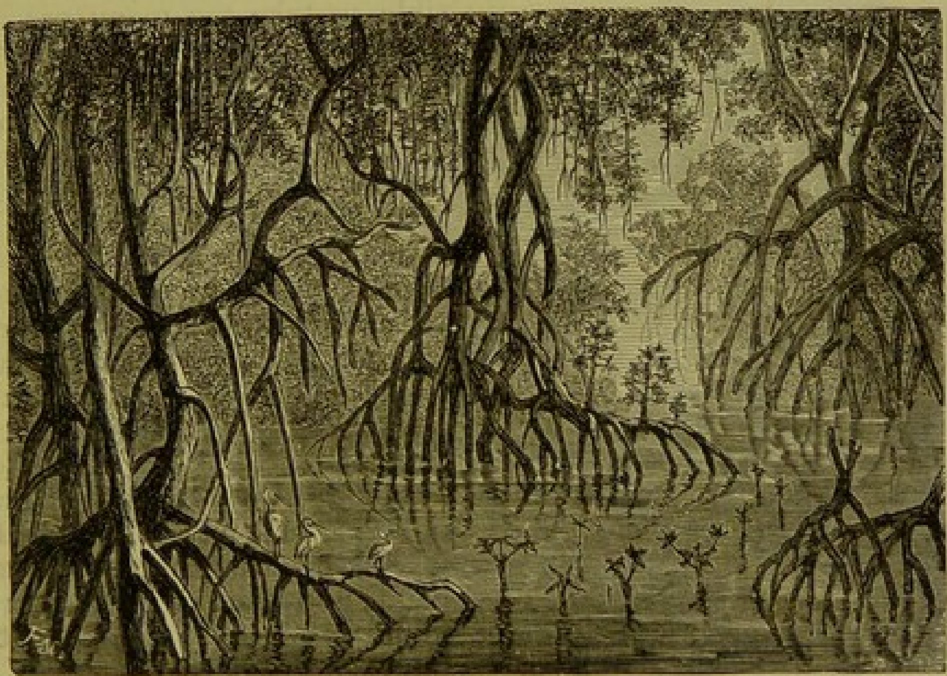
The history of cinnamon growing is scarcely within the scope of our present subject, but a few words upon the subject may be welcomed as giving a curious example of human perversity. Under the native princes, cinnamon was a monopoly; and when, in the beginning of the sixteenth century, the Portuguese appeared in Ceylon, Almeida imposed upon the native sovereign, Dharma Praakramabahu the ninth, then residing in Kotta, a tribute of 250,000 lbs. of cinnamon, in exchange for which he was assured of the protection of the king of Portugal, Don Emanuel. As the power of the Portuguese increased, the trade in cinnamon became one of the largest items in their income. With the prohibition of Phillip II. to have any dealings with the rebellious provinces of Holland came the first appearance of a Dutch fleet, half merchant, half military, in the Indian Ocean. The Portuguese were gradually driven out of the markets, and in process of time out of their possessions. As lords of the island, the Dutch now upheld the monopoly with rigorous jealousy. No one was allowed either to plant or to gather. Landed proprietors were compelled to inform the inspector whenever a cinnamon bush appeared on their property. Any evasion of this law was punishable by fine or imprisonment. For a century long the monopoly was enjoyed by the Dutch, and brought them in a yearly income of £400,000. In order to render it still more lucrative, and to make it wholly independent of the sovereigns of Candy, who often ill-treated the cinnamon gatherers, and drove them back from their forests, the Dutch began to cultivate it themselves in 1765. Cinnamon gardens were planted by the government from Matura and Galle along the western coasts; the largest plantation being made in the neighbourhood of Columbo. The natives resisted the attempt, the chiefs declared that the cinnamon would degenerate as soon as it was cultivated artificially. The real reason of their opposition was the fear of losing the percentage which they received from the Dutch on the cinnamon, furnished by them from those lands in the interior, which they still held as fiefs. The plantations promised exceedingly well, when all at once the plants died, and it was found that the roots had been watered with boiling water. Terrible punishments followed this crime, and severe penalties, such as the cutting off of the right hand, were pronounced upon any person who should injure a cinnamon plant. This Draco-like severity saved the undertaking.

Towards the end of the Dutch rule in Ceylon, the cinnamon plantations yielded already 400,000 lbs. and conclusively proved the possibility of becoming independent of the wild cinnamon gathered by the natives. The speculation returned 200 per cent. profit. The monopoly still remained exclusively in the hands of the Dutch, who destroyed all the cinnamon in excess of the yearly demand, so as to keep up the price; a policy which, we may add, they followed in reference to several other plants of the Sunda Islands. The cinnamon gatherers were divided into many castes, and lived under a terribly oppressive rule. Every male was compelled from his twelfth year upward to furnish 56 lbs. of cinnamon, an amount increased as he grew older to 616 lbs. Anything beyond this quantity was paid for separately, but for the ordinary cinnamon tribute the natives received only a few rations of rice and exemption from taxes. The wretched men strove to escape from their burdens by emigration or hiding in the forests. The English made over their monopoly to the East India Company in return for a yearly sum of £60,000 until the year 1873, when the colonial government took the trade into their own hands. In 1831, the produce of the cinnamon gardens had decreased to £16,000. The taking of Candy greatly depreciated their value, because large quantities were obtained wild from the woods. In 1832 the government gave up the monopoly, and the forced gathering by the chalias (native gatherers); but an enormous duty was imposed upon the spice, namely, two shillings a pound, or more than twice the worth of that quantity upon the spot where it was gathered. As, however, excellent cinnamon is obtained from Java and Malabar, and also from Cochin China, there arose a strong competition in the various markets, and the duty was gradually lowered until the year 1853, when it was finally withdrawn.

FURTHER INDIA.

The valley of the Brahmapootra and the Khasia mountains form a chain of connection between Hindustan and the Malayan peninsula. If the flora of the Himalayas contains already a mixture of Indian plants, together with those of northern and central Asia, the floras of the Himalayas meet here those of the Malay region. This landscape is pronounced by Hooker to be the richest of all India, and probably of all tropical Asia. Two thousand species have been collected by him near Churra Punjee. The Indian botanist recognizes as the type of the Malayan flora, the evergreen laurel so abundant in the jungle. 250 sorts of orchids, 150 ferns, and numerous palms are found in the jungle, while on the table-land the pandanas and various grasses predominate. The coast of British Burmah is covered with extensive mangrove forests bounded by grassy plains, which lie under the water in the rainy season, and at other times are so dry that the least provocation causes them to break out into flames which rage many square miles. These grassy thickets are generally about sixteen feet high. On rising ground, or in the plains drained by rivers, rice fields are seen, with villages lying in their midst overshadowed by fruit trees. It is only in the interior of the country, or upon sandy soil, that artificial irrigation is needed for the cultivation of rice. Agriculture is carried on in the hill countries and on the mountains; the woods are cut down, and the ground cleared by fire, after which, when it has yielded the desired harvest, it is left to itself again for a few years, and then subjected once more to the sharp treatment of axe and flame. If the rainy season is delayed, the wind blows away the ashes and the seed together; and if it comes too soon, it finds the ground insufficiently cleared:

while in either case failure of the harvest brings down famine upon the land. The living inhabitants of these primitive fields are elephants, buffaloes, and mosquitoes. The woods, up to the height of 3,100 feet, are partly evergreen, partly leafless in the dry season. Among the latter class are the noble forests of teak, from which more than 100,000 trunks are obtained every year. On large tracks the average height of the trees is sixty-five yards, and the forest forms a nearly impenetrable mass of green foliage from the ground to the top of the trees. Above the height of 3,100 feet, on the mountain chain between the Saluen and the Irawaddy, are extensive forests of conifers, specially of *Pinus Khassyana*. Here and there agriculture is carried on, and even rice fields are cultivated up to the height of 4,600 feet above the level of the sea. At the same height lie wide stretches of grass land covered with ferns, apparently the same as that known in Germany under the name of *Pteris aquilina*.



MANGROVE SWAMP (*Avicennia tomentosa*).

Some of the most remarkable productions of Further India are gutta-percha, and gum-lac, eagle wood. The gutta-percha tree (*isonandra gutta*), which belongs to a family of ebony plants, grows to the south of Pulo Pinang, on the coasts of Malacca, as well as in Sumatra, Borneo, and other East Indian islands; the gutta-percha of commerce is the thick milky juice which flows from incisions made in the tree. Gum-lac is obtained from several plants, and is a liquid flowing from the wounds made in the bark by the sting of an insect (*coccus lacca*); the trees which contain the gum are some of the fig tribe (*ficus religiosa* and *indica*), and especially from the gum-lac tree, a member of the wolf's milk family (*aleurites laccifera*). Eagle wood (*aquilaria agallocha*) is a hard variegated wood, which has a fragrant scent when burnt, and is used as a medicine, and also for the fumigation of the corpses of princes and persons of rank.

The interior of Further India is little known. Tickell describes the lower bank of the river Koladyn as covered for about fifty to a hundred yards wide with jungle, which not only blocks up the prospect, but makes it almost impossible for the traveller to believe that he is in the midst of a populous and highly cultivated country. The river is full of crocodiles, most of which seem to belong to a different species from those found in Bengal; but, like those of the Ganges, are swift and agile swimmers. The shores of the Delta, which are left dry at low tide, are alive with numbers of sea cats (*Circopithecus carbonarius*), a kind of monkey, busy in the pursuit of worms, crabs, and other crustaceous animals. Bastian, to whom we owe most of our knowledge of the ethnography of Further India, says that the forests of the province of Pegu are celebrated for their extent and abundance of fine trees, and for the elephants which are employed for the transport of the teakwood. Mouhot, who has devoted much attention to the natural history of Siam, speaks of the terrors of the jungle fever. It is something terrible, he tells us; the burning heat is felt down to one's finger tips, and can only be described as "infernal." This fierce heat alternates suddenly with cold fits, and the result to the European patient is generally fatal. During the rainy season, it is impossible to take too many precautions against the numerous snakes which infest the country. Sitting or standing, one is in continual danger of setting one's hand or foot upon a poisonous snake. "More than once," says Mouhot, "I have killed one in my hut, either with an axe or a gun. While I write I am constantly on the watch for the return of a snake upon which I trod as I entered the hut, and which slipped out at the door without injuring me." We must not linger over the description of Lake Suli Sap, called by Mouhot the "Paradise of cormorants and pelicans." In this lake Bastian saw the fish captured by hand; and Mouhot asserts that their numbers were so great that they impeded the rowers!

GUTTA-PERCHA TREE (*Isonandra gutta*).

Harmand, the latest explorer of this part of Asia, prevailed upon the natives to accompany him to a plateau little known to travellers, and of evil repute among the inhabitants, which they did on condition that no gun was to be fired off nor anybody beaten, both considered unlucky omens. They turned aside into a mountain pass running from the west, and separating the mountains of Phu-Luang from the more northern chain of Phu-dak-ling. The way led at first through dense thickets of bamboo, and then gradually rose to a height of 1,950 feet. In this ascent the elephants behaved admirably, shewing a lightness and agility wonderful to see in such massive creatures. The grand beasts quietly descend the smooth rock, or climb upward over tree trunks and indescribable *débris*, where the ascent or descent is so steep that it seems as if they must slip off either backward or forward. If the way lies along the edge of a precipice, they test every step with their fore-feet, before trusting it with their full weight; suspicious places are examined with their trunk, and all is done without any sign of effort or timidity. At length the high table-land is reached. The first glance shews that the character of the vegetation has entirely changed. In place of the *Dipterocarpeæ* of the plains, oak, chestnut, and white beech trees are seen, the track is edged with thick brambles, bearing a pale golden fruit, and the short turf of the clearings is adorned with crowsfoot and violets. But among these children of the temperate zones rise the betel, sago, and rotang palms, while the tree ferns wave their graceful leaves above the ravines. The place is a true paradise for the botanist; the beautiful foliage of the styrax is seen among different kinds of firs and other coniferæ (*Podocarpus*). The woods must, however, be absolutely impassable during the rainy season, from the great number of leeches found within them. Deer are rarely seen, and Harmand discovered no traces of tigers, panthers, or elephants: probably the cold of the nights is too severe for them. The natives are armed with poisoned arrows; they extract the poison from a strophantus, belonging to the family of the *Apocyneæ*, and also from strychinæ.

Instead of further details, which would not give anything new of importance, we will give here the produce of the different parts.

In the year 1862, the following productions were exhibited in London from Assam:—Rice and cotton; then, but in far smaller quantities, shell fish, crabs, trepang, fish, salangane, or edible swallows' nests, fins of the white and black shark, tortoiseshell, wax, bufflaloes' horn, elephants' teeth, peacocks' feathers, pelicans' feathers for pens, beans, pepper, cardamom, sugar nuts, palm nuts, sesam, wild almonds, sandal wood, eagle wood, lac, different kinds of gum, hemp, tobacco, and mangrove bark. And yet it is said that of the 12,800 square miles of territory, only 880 are cultivated, 700 of which are taken up with rice fields.

Laos grows rice, maize, gourds, melons, sweet potato, red pepper, vegetables, and betel.

South Tonquin furnishes rice, cotton, mulberry, sugar-cane, maize, tea, and betel; but its chief exports are different kinds of timber, such as ironwood, etc.; cinnamon is a royal monopoly. Banana, guava, orange, citron, and cocoa are also exported. The principal animals are elephants, tigers, rhinoceroses, apes, porcupines, peacocks, pheasants, and parrots, together with the sperm whale, which is found in the harbours, and looked upon by the natives with religious veneration.

Pulo Pinang, an island near the coast, exports rice, pepper, cloves, nutmeg, betel, tea, cotton, tobacco, coffee, sugar-cane, and mango, besides cocoanuts, obtained from the forests which fringe the island.

Siam exports the produce of the sago, palmyra, and cocoa palms, teak, bread-fruit, mangrove bark, gutta-percha, besides numerous fruits. Its principal objects of culture are rice, sugar-cane, tea, maize, mustard, pepper, and cotton.

Singapore exports sugar, rice, spices, and gambier. The latter article (*nauclea gambier*) is an extract obtained by boiling the leaves and young twigs of a climbing plant, which is known in the market as kino, or terra japonica. The island is unenviably notorious for its numerous tigers, most of which are supposed to swim across from the mainland.

If we turn our attention to the fauna of Further India, we see by a glance at the map that part of the monsoon district extends beyond the limits of the Australian region; while the latter, as if in compensation, comprises part of the desert and Chino-Japanese region. It is extremely rich in mammals, especially in quadrumana, possessing numerous varieties of apes, ourang-outangs, gibbons or long-armed apes, dog-monkeys, and others allied to the lemur (*Semnopithecus* and *Macacus*), with the lemurs (*Nycticebus* and *Loris*), and many of the tarsiidæ. The greater part of this interesting fauna is restricted exclusively to this region, and is found more especially in Malacca and the island world; that is, in the Malayan subdivision. There are no less than thirty genera of bats, of which the most important is the "flying fox" (*Pteropus edulis*). The region is very rich in insectivorous animals, among which are the galeopithecus, the squirrel-like insectivoræ *Tupayæ*, and the *Cladobates tana*. Among the carnivora are lions, tigers, panthers (*Leopardus panthera*), and the long-tailed panther (*Leopardus variegatus*). The leopard is confined to Africa, and is never met with in this region. The *Viverridæ*, or civet-cat tribe, is represented by ten genera, the best known being the true or Asiatic civet-cat (*Viverra zibetha*) and the *Viverra indica*, *Paradoxurus hermaphroditus*, *Paradoxurus fasciatus*, *Cynogale Benettii*, *Herpestes griseus*, *H. javanicus* and *canerivorus*. The panda, cat-like in form, but allied to the bears, is also found here. Wild cats are represented by the *Felis minuta*, or dwarf cat, and the tarai (*Felis viverrina*); the striped hyæna (*Hyæna striata*), wolf, jackal (*Canis pallipes*), fox, martens, the skink (*Midans melliceps*), bears, and wild dogs, complete the list of the carnivora. In the mountainous districts of the Himalaya the yellow bear (*Ursus isabellinus*) is found. This animal is probably only a variety of the common brown bear. In the same mountains and on the islands is found the *Ursus torquatus*. The home of the Malayan bear (*Ursus malayanus*) is pointed out by its name. The continent of Southern Asia and the island of Ceylon are the home of the *Ursus labiatus;* and among the smaller bears are the *Arctitis binturong* and the singular cat-bear or panda, of which we have spoken before. The *Cuon dukhunensis* of the jungle, one of those animals which have been honoured by scientific men with the reputation of being the primitive ancestor of the domestic dog; the *Cuon primævus*, found in the thickets of the Himalaya, and the *Cuon rutilans*, represent the race of wild dogs. The Platanista dolphin (*Platanista gangetica*) is peculiar to the Ganges. The deer tribe are represented, among others, by the *Tragulus*, the magnificent *Cervus duvaucelli*, the white-spotted *Cervus axis*, *Cervus Aristotelis*, the maned stag (*Cervus Hippelaphus*), the boar stag (*Cervus porcinus*), and the *Cervulus muntjac*. Antelopes and goats are represented by the large, imposing *Capra megaceros*, the wild goat of the Nilgherries, or *Hemitragus hylocrius*, the *Hemitragus jemlaicus*, the Nilgan antelope, or blue ox (*poriax pictus*), the *Nemorhœdus goral*, and the *Nemorhœdus bubalinus*; but these species are relatively local, and confined to one district, and are not characteristic of the whole region. Wild oxen are found everywhere, and form, with the rhinoceros and the elephant, distinguishing types of the fauna. Wild boar and tapirs are numerous, and although the rodents are not especially remarkable, there are numbers of hares and squirrels, together with many varieties of porcupine (*Hystrix* and *Ætherura*). The armadillo, *Manis pentadactyla*, or pangolin of Malay, is more rarely found.

The tribes and genera of birds which form the distinguishing features of Indian bird life are so numerous and diverse, that it will be impossible to do more than mention the most important varieties. Throstles (*Simolidæ*) are met with everywhere, and are represented by more than twenty-one genera. The elegant swallow-tailed wagtail (*enicurus*) and the rich blue-tinted mycophonus, although comparatively rare, are not yet very characteristic of the Malayan and Indo-Chinese fauna. The beautiful little hill-tits, bulbul (*Liotrichnidæ*), are found in every part of the hill country. The green bird Phyllornis, together with the different species of bulbul (*Pycnotidæ*), the black and crimson varieties of *Pericrocotus*, the brilliant king crow (*Dicrurus*), the long-tailed urocissa, and the magpie (*Dendrocitta*), represent some of the most interesting and characteristic forms of the crow tribe. Sunbirds (*Nectarinidæ*) are found throughout the whole region; the lovely little flower kissers (*Dicæidæ*), and a few rare varieties of weaver birds (*Ploceus* and *Munia*). Among the starling tribe, the brilliant eulabes are the most remarkable. Very striking, also, are the different species of *Artamus*, or swallow-shrikes, the magnificently coloured ground thrush (*pittidæ*), and the bright-tinted gapers (*Eurlæmidæ*). Leaving the passeres, we come next to the woodpeckers, wattle-birds, and cuckoos, which are found everywhere, and often in peculiar and remarkable varieties. The principal specimens of the bee-eater are the beautiful *Nyctiornes*, with their long neck feathers of bright blue or scarlet. Brilliant kingfishers and oddly formed hornbills (*bucerotidæ*) are also found in great numbers; while the brown-backed trogons, with scarlet and orange-coloured breast, though less frequent, impart a special character to the bird-world of India. Besides these beautiful birds, we must mention the frog-billed goat milker (*batrachostomus*), the Salangane (*Callocalia*), with their edible nests, and the bearded bird (*dendrochelidon*), all of which represent widely distributed, remarkable and characteristic groups. Passing over the parrot tribe, we find the long-tailed palæornis and the blue-crested coryllis. Among pigeons, the most remarkable are the fruit-eating varieties—*Carpophaga* and *Treron*. The fowl tribe is very numerously represented: among other forms we find the peacock (*pavo*), the ocellated pheasant (*argusianus*), the fire-backed pheasant (*euplocamus*), and the jungle fowl (*gallus bankiva*), which may conclude our sketch for the birds of prey; and water fowl do not offer anything specially characteristic of the region, although there is no lack of vultures, kites, hawks, buzzards, eagles, milans, falcons, river eagles, owls of every kind, plovers, herons, cranes, swans, geese and other genera. All these species, however, are cosmopolitan, or at least are found distributed over the greater part of the old world.

It is not necessary to mention more than the principal species and most characteristic groups of reptiles. The snake tribe is very numerous, and is distributed over the whole region in great varieties of form and species. We find among others a little tribe of earth snakes, fresh-water snakes, tree snakes, and rock or python snakes. Among the larger kinds is the formidable *python tigris*, or tiger snake, often nearly 34 ft. long, and the snake of the rice plantations (*python reticulatus*), which is of equal size with the python tigris. Besides these, we must mention the poisonous *Naja tripudians*, and many other venomous snakes and adders.

Among the many varieties of lizards, the groups most widely spread and deserving of notice are the skinks and geckoes. The "flying dragon" (*draco volans*) is an animal resembling a lizard, which possesses thick leathery wings attached to its sides by false ribs, a formation which is not found in any other animal; for the rest it is a comparatively insignificant little creature, measuring about eight inches long, and having nothing in common with the dragons and griffins of romance beyond its somewhat pretentious name.

As to crocodiles, the true crocodile is found throughout the greater part of the region, and the long-snouted gavial is characteristic of the Ganges.

Frogs and many varieties of tortoise are also common.

Among the fresh-water fish, the most characteristic and deserving of attention are the so-called labyrinth fish, the snake-headed fish, shad, and especially the carp.

The brightest and most beautiful ornament of the insect-world is the butterfly, which is richly represented in many of its loveliest kinds. Next to these, the attention of the naturalist has been principally claimed by the numerous kinds of the beetle tribe. Of course there is no lack of mosquitoes. Another plague of these regions are the leeches. Among the spiders, one of the most numerous varieties, principally found in Java, is the *Gasteracantha arcuata*. The sea is rich in pearls.

A more detailed consideration of the fauna of the zoological subdivisions is not necessary; it is enough to say that the Sunda Islands are principally distinguished for their monkeys; that Ceylon and the south of Hindustan are rich in snakes; that the Indo-Chinese subdivision is the richest in animal life, and the subdivision of Hindustan the poorest.

Of all the characteristic animals of India, the elephant (*elephas indicus*) claims our greatest attention, both by its imposing appearance and by its intelligence. Although the Indian elephant has been used for the service of men in various capacities for so long a time, the question as to whether all the elephants of the continent belong to one and the same family is yet undecided; nor is it yet clear in what relation the Indian species stands to those of Sumatra and Africa. The presence of Europeans in India was for many years restricted to the coasts, and afforded no facilities for the investigation of these and similar questions; and although the African elephant is now considered to belong to a different race, the discussion as to his Indian namesake is still undecided, notwithstanding the fact that the elephants of Northern India have only thirteen false ribs, and those of Sumatra fourteen. The elephant inhabits forests by preference, but is by no means restricted to them; it seeks out the most densely grown and best watered districts, caring little whether they are found on high or low ground; so that it is at home in the table-land of Urah in Ceylon, covered with hoarfrost at 6,500 feet above the level of the sea; and Van der Decken, when ascending the Kilimandscharo, found traces of the African elephant at the height of 9,800 feet. Even the veteran traveller does not always climb the loftiest heights without an accident, and yet elephants have been led over them. The principal food of these animals is the leafage and young shoots of the different kinds of figs (*ficus indica*, *religiosa*, and *racemosa*); from other plants, such as the *cochlo-spermum gossypium*, they strip the bark, and they also eat the roots of the bamboo. Rice is, however, their favourite article of food, and they will often devastate whole plantations. Fortunately the simplest kind of scarecrow or the slightest fence is enough to keep the great creatures away from the crops. The Hindoos lay down paths for them to pass through on their way to get water, and fence the track with cane: a single blow of the trunk of a passing elephant would overthrow the whole fragile structure, but it is always respected, and the herd tramp through without doing any damage. Sometimes a solitary "rogue" breaks down the enclosure, but it is never interfered with by the herd. After the rice harvest the Indians take away the fence, and the elephants eagerly rush into the fields, eating up the empty straw and clearing away everything that is left. This clearing away is by no means a noiseless process. What with the breaking down of the trees, the cracking of the larger branches and trunks, the chewing and loud breathing, the trampling of the heavy feet in the swampy soil, the splashing of the water drawn into the trunk and thrown over the body, the flapping of the enormous ears, which are often spread out like umbrellas, the rubbing against rough trees, and the occasional bellowing and deep-trumpeting of one or another of the herd, the result is a truly indescribable and deafening combination of noises of every kind. The devastation wrought by a herd of elephants passing through a plantation passes all description. All that is not trampled down out of all shape under their heavy feet is overturned, the strongest trees uprooted, their branches broken, the undergrowth torn and trodden down as if a whirlwind had passed over it; stems which have braved the storms of centuries snapped like reeds. The male elephant attains its full growth at about twenty-five years of age, but its size is greatly exaggerated. Very large animals measure about twenty-two feet from the tip of the trunk to the end of the tail, the trunk measuring about six and a half feet, and the tail rather more than three feet; they stand from eleven to thirteen feet high, and their weight varies from three to four tons. The average length of life enjoyed by wild elephants is said by some writers to be a hundred years; according to Campbell, eighty-five. On the approach of sickness, the animal withdraws to the interior of the forests; and as the latter are inaccessible to men, dead elephants are never found in the forests, which originated the fable that the elephants buried their dead. The Indian elephant has been domesticated for thousands of years. History speaks of their having been used by Darius Codamanus against Alexander the Great; the African elephant was also tamed and led across the Alps by Hannibal, in his wars against the Romans. Even now they are widely used; and since the art of taming the African elephant has been lost, the Indian animal has been successfully introduced into Africa to assist in the exploration of the "dark continent." At the present day the markets are principally supplied with elephants from Assam; one of the most important stations of the elephant trade being the fair at Nek Mured in Dinapore, which is held in April. In former times, elephants were captured in pits, but the lasso is now more generally used. A camp is fenced round, and the elephant hunters reconnoitre the ground morning and evening, searching thickets and open clearings wherever there is any likelihood of finding the desired animals. Every band is accompanied by three or four tame elephants trained to the chase. As soon as a herd of wild elephants is seen, the men select one particular elephant to be captured, and endeavour to bring one of the tame beasts on each side of him. When this is done, the *phanaits*, or huntsmen, who are mounted upon the tame elephants, throw the lasso over the head of the wild animal, and ride off in opposite directions, until the captured elephant falls almost strangled to the ground. Very often the frightened and desperate animal rushes madly forward, and is not caught until after a long chase. Its pursuers then give it a little air, and it is again placed between the two trained elephants, and slowly driven into the fenced camp, where it is tamed by hunger and ropes. In about six weeks it is already so far vanquished as to be able to march farther on, and to endure a rider. But in this half-domesticated state the elephants are subject to many unknown diseases. They become very thin during the first half-year of captivity, and the rainy season proves fatal to many of them, sometimes destroying the capture of a whole year. On an average estimate, about eight times as many females as males are captured, but the price of the males is twenty-five per cent. higher, on account of their greater strength and endurance. The hunting season lasts from November to July, but by far the greater number of animals are captured in June, when the elephants come to look for the fresh grass. In good years the hunters bring back as many as 180 animals, but in bad seasons they only obtain fifty or sixty. The capture of whole herds, by driving them into strongly fenced enclosures or corrals, is only feasible by princes, as it is a very expensive proceeding, and consequently seldom undertaken.

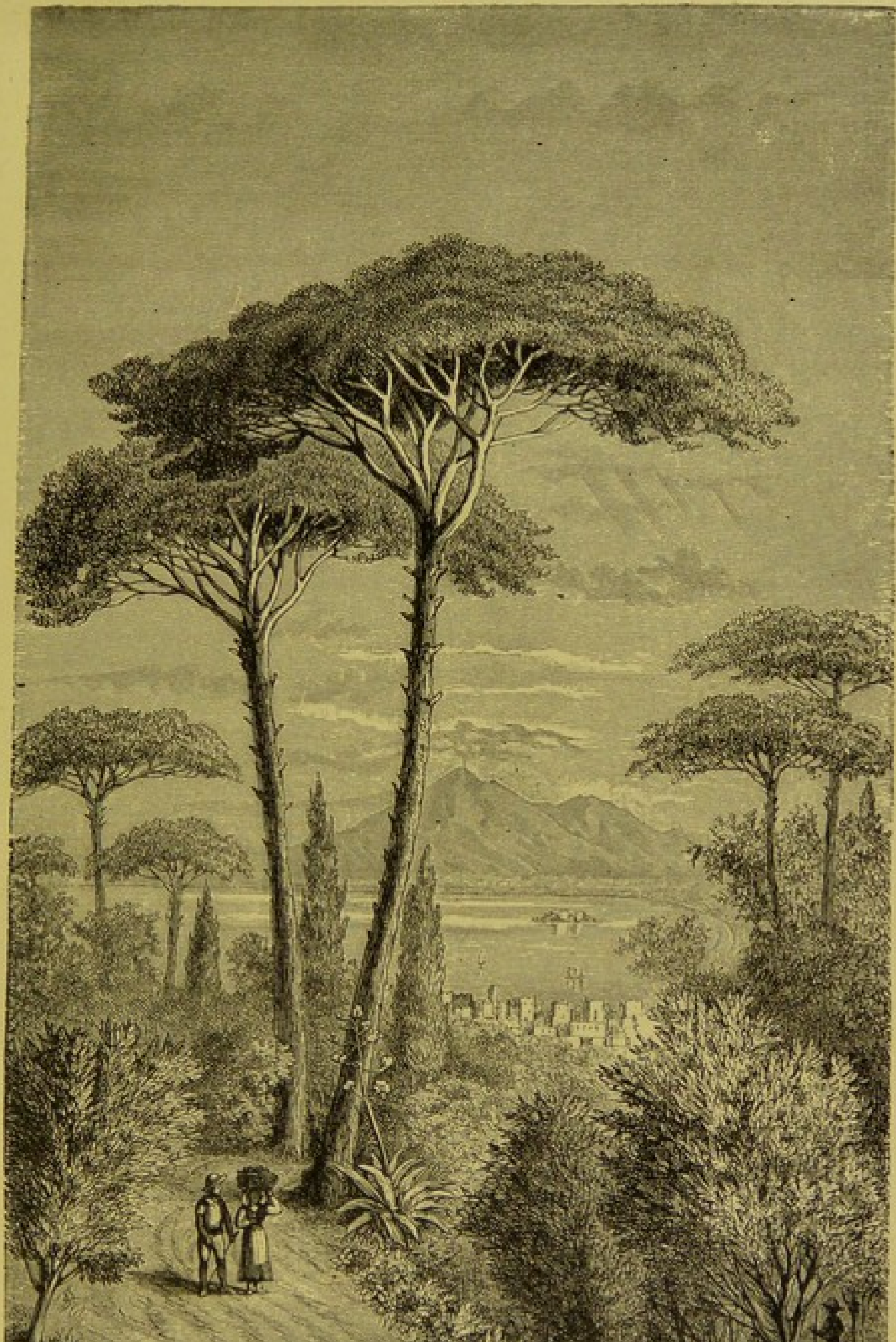
Turning aside from this typical Indian animal, we must next mention the carnivorous species and the poisonous serpents and snakes which make up a chief part of the characteristic fauna of the East. Their importance to India may be understood from the following particulars, given by Colonel Wagg. When the price of cotton rose so persistently during the war between the northern and southern states of America, and it was no longer possible to supply the necessary raw material for the immense consumption of European towns, the attention of those interested in the trade was directed towards other countries which seemed fitted for the growth of cotton. Attempts had been previously made to cultivate this valuable plant in the East Indies, and they were now renewed upon a larger scale; when it was found that the new culture was exposed to dangers of a kind, and from a quarter, which had not been foreseen. The natives were subjected to so many attacks from wild beasts, both in the fields and during the transport of the goods, that in some parts of the country they refused to work in the plantations. Their reluctance needs no explanation in face of the following statistics. In the short space of three years (1866-68), more than 888 men and 52,500 head of cattle were destroyed in the presidency of Madras alone; and yet the government paid a yearly premium of £3000 for the carcases of wild beasts. They offered £10 for a man-eating tiger, £7 for a dangerous elephant, £3 10*s.* for a royal tiger, £1 15*s.* for a cheetah (*Tschitah*), probably a word meaning the spotted beast, and consequently panther and leopard; 14*s.* for a bear, 10*s.* for a wolf or a hyæna, 1*s.* for a jackal, and 3*d.* for a poisonous snake. Considerable as these rewards may seem, to many a huntsman they were by no means excessive. There is a wide field open to any daring Nimrod; and in the years of which we are speaking, 3 elephants, 1,027 tigers and panthers, 774 bears, 535 hyænas, and 106 wolves were killed, not to speak of smaller game which were not reported. The different beasts of prey are distributed unequally throughout the land. In the district of Gamgam, 446 bears were killed, while only 118 were slain in the district of Bizagapatam, and only 55 in the district of Kurnul. In South Canara, 499 tigers and panthers were killed, 125 in Bizagapatam, and only 28 in Kurnul and its dependencies. In this place, 80 panthers and 41 wolves made up the list of killed animals; not before 97 men had fallen victims to these wild beasts. In Cuddapore, 72 panthers and 22 wild boars were killed; and in the Nilgherrie hills, 38 tigers, 9 bears, and 42 other wild beasts.

In a certain part of Kurnul, the tiger is so completely master of the land, that no one dares stir abroad without a strong escort. The cotton plantations themselves are not injured by the tigers; but the natives who walk through them, or are engaged in the work of cultivation, are perpetually exposed to their attacks. The result was, that while in the year 1868, 245,000 acres of land in the district of Kurnul were devoted to the growing of cotton, in the year 1870 the number of acres was diminished by more than one-third. The case is almost worse in the district of Bizagapatam, where the amount of land occupied by the cotton plantations in 1870 was diminished by nearly one half in the following year, because 148 persons had been carried off by wild beasts. In the district of Madura, only 21 persons lost their lives in this manner, and the number of acres where cotton was grown in 1869 (8000 acres), increased to 40,000 in 1870. It is not only the larger carnivora that endanger the lives of the labourers; in some parts of India there is more to be feared from the presence of poisonous snakes. In the presidency of Madras, during the years 1866-68, 760 persons perished from the bite of venomous snakes. To this terrible list we must add that 1815 head of cattle were destroyed by snakes and serpents. About 21,000 of these dangerous reptiles were killed, for which the premium paid was only £130; and it cannot be doubted that, if a higher reward were offered, the safety of the native workmen would be far more effectually assured. Any one who receives only a few pence for a deadly snake will feel more inclined to escape than to fight when attacked, especially if he has time to reflect that the struggle may be of doubtful issue; and that, even if successful, he will have to drag the great heavy snake for a long distance under the burning sun before he can receive his scanty reward from the official tax collector. In Malabar, the danger to be apprehended from venomous snakes is much greater than from wild beasts. The latter are generally found only in thinly populated regions; besides which every native is continually on the watch, and prepared with every necessary precautionary measure, so that accidents of this kind are of rarer occurrence. But in the populous districts, where every hut is surrounded by the luxuriant growth of tropical plants, the deadly reptile finds countless lurking places. The rich undergrowth is intersected by narrow paths running in every direction; and nothing is easier than to set the foot upon some hidden snake, who answers with the deadly silence of his sting. The chase of the larger carnivora is made much more difficult by the rotang palms, beneath which they can seek shelter in safety. But the hunter, impeded by the thorny tendrils, the sharp spear points of the leaves, and the still stronger thorns which beset the way, climbing from tree to tree, and hooking themselves on to every branch, finds the Indian jungle so impenetrable, that he has to cut his way through it almost step by step.

Statistics are published yearly, giving the number of lives lost in India by the attacks of wild beasts, and every year fresh astonishment is expressed in Europe at the number of victims. The devastations were unusually terrible in the year 1879, in the presidency of Bengal: there were no less than 1,264 human beings destroyed by wild animals, and 9,515 by serpents; and more than 12,000 head of cattle were carried off during the same period. The figures shew a deplorable increase when compared with those published in 1878, except that fewer persons were devoured by wolves, the numbers for each year being 152 in 1878, and 83 in 1879. The same official report states that 5,543 wild animals were killed in 1879, and 21,102 snakes (against 24,276 in 1878). But it must be remembered that the report only takes account of those snakes for which the government reward was paid.

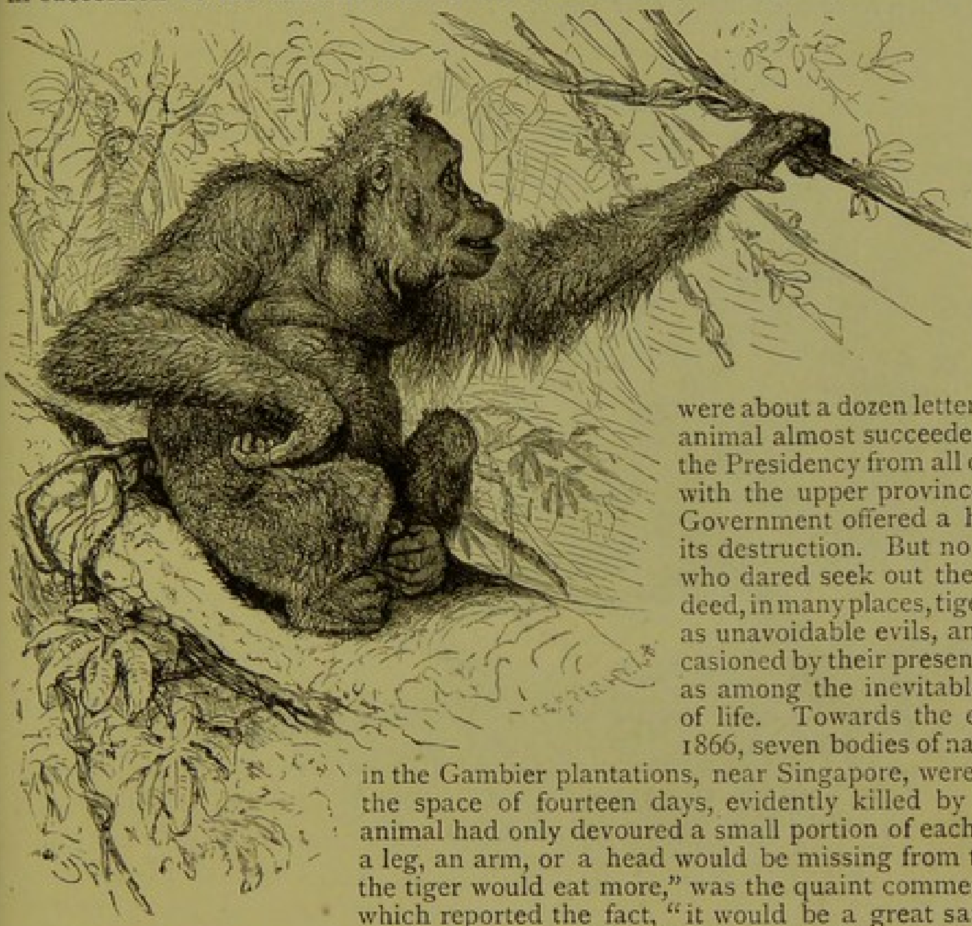
As to lions, the royal king of beasts is seldom found in India, where he is represented only by the small maneless lion of Gujerat, a reddish, dun-coloured animal, called by the natives the camel lion (*Leo googratensis*). It is not yet known how widely this lion is distributed through India. It is found in Gujerat, principally in the jungle forests which skirt the banks of the river; but although frequenting the woods in great numbers, the natives seem to know but little of its habits, and lay down most of its depredations to the charge of the tiger, the most daring robber which we met already in Siberia and in Central Asia.

The tiger (*Felis tigris*) is one of the boldest, most dangerous enemies of mankind. Under some circumstances it is said to shun the presence of men, and to avoid an attack;



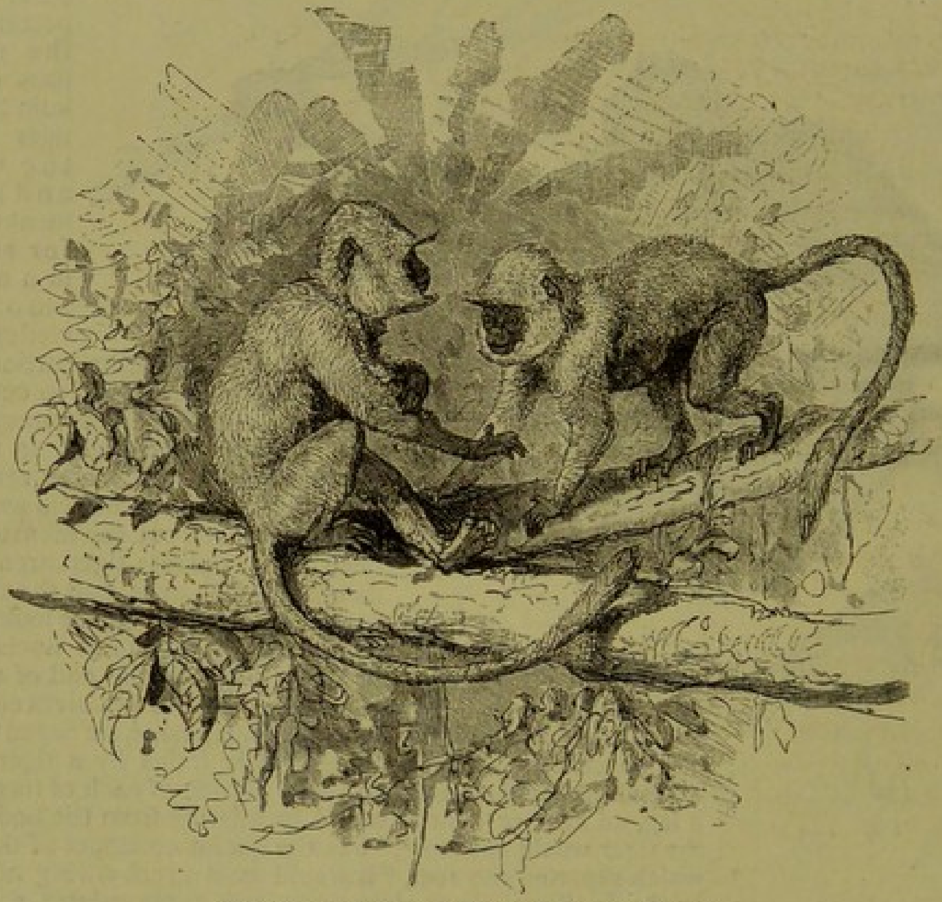
PINES.

but such a retreat is caused either by satiety and consequent indolence, or by the terror of a sudden surprise. A tiger who sees a man for the first time generally takes himself off, and it is said that a loud cry has been known to scare the animal away. But experience teaches it only too soon that man is an easy and defenceless prey, and the fear of man once lost, the tiger becomes so dangerous, that the native women, when pursued, have been known to abandon their children in order to save themselves. Most to be pitied are the people whose occupation obliges them to frequent the woods, such as shepherds and the collectors of sandal-wood. The former live in perpetual terror, not only for their flocks, but for themselves; and the greater number actually lose their lives by the attacks of tigers. The letter-carriers are also exposed to fearful risks. Those who have to carry the mail-bags through the woods by night are never safe unless escorted by torch-bearers, lancers, and the continual sound of drums; and even then they are too often attacked and carried off, in spite of their escort. At one time the letter-carriers were carried off for fourteen days in succession at the difficult ford of the river Gunna, in Gujerat, and once the mail-bags were taken instead of the postman. In the narrow pass of Kutkum Sandi, a tiger lay on the watch, and killed men every day for several months; among the victims there were about a dozen letter-carriers. This animal almost succeeded in cutting off the Presidency from all communication with the upper provinces, so that the Government offered a high reward for its destruction. But no one was found who dared seek out the monster. Indeed, in many places, tigers are accepted as unavoidable evils, and the risks occasioned by their presence looked upon as among the inevitable uncertainties of life. Towards the end of the year 1866, seven bodies of natives employed in the Gambier plantations, near Singapore, were found dead in the space of fourteen days, evidently killed by a tiger. The animal had only devoured a small portion of each of its victims; a leg, an arm, or a head would be missing from the body. "If the tiger would eat more," was the quaint comment of the paper which reported the fact, "it would be a great saving of human life." In Siam, about sixty years ago, there existed a kind of "ordeal by tiger," which was conducted in the following simple fashion. Two persons suspected of a crime were thrown before a tiger, and whichever the animal ate was supposed to be guilty. If the tiger was thus regarded as the avenger of crime, other animals, and especially certain kinds of apes, were exalted to the rank of objects of worship. The jackal is a characteristic denizen of the Indian forests; it prowls through the land by night, generally in bands, devouring dead bodies and every kind of carrion, and working considerable havoc among the smaller kinds of domestic animals. Its gluttony is proverbial; it eats everything that comes in its way, even wild fruits; and in some districts of southern India it is a dangerous enemy to the coffee plantations. Its penetrating cry, a sound something between a bark and a howl, makes the night hideous.



ORANG OUTANG.

The sacred monkey of the Hindoos is known by many different names. The Mahrattas call it *Marbur*, the Hindoos *Hulman*, and the natives of Malabar *Mandi*. Its zoological name is *Simia entellus*. The natives look upon it as a god, and it is not only spared from every kind of attack, but protected and carefully tended. As a natural consequence it is more numerous than any other kind, and is most frequently found in most of the districts of Lower India. Attempts have even been made to acclimatize it in other places, but it is only found on the other side of the Ganges and the Jumna, not in the Himalayas. The length of the full-grown male is five feet, about thirty-nine inches of which are taken up by the disproportionately long and tasselled tail. The colour of its coat is a yellowish white, the bare parts of the skin being of a dark violet. The hands, feet, and face are black wherever they are overgrown with hair, and so is the thick hair which overhangs the eyes: the short beard is of a pale yellow colour. This monkey takes the first rank among the thirty million deities of the Hindoo nation, and has enjoyed this honour for time out of mind. The giant Ravan, so says the ancient Indian saga, carried off Sita, the wife of Schri-Rama, and brought her to his dwelling on the island of Ceylon, but the monkey delivered the goddess from her captivity, and restored her to her husband. Ever since that time the monkey ranked as a hero. Wonderful stories are related of his intelligence and swiftness. He is reverenced also as having introduced the mango, a fruit which he is said to have stolen from the giant's garden. As a punishment for this theft, the saga goes on, he was sentenced (by whom is not said) to be burnt alive, but he extinguished the fire, scorching, however, his face and hands, which have been black ever since. The worship paid to this sacred animal



THE HULMAN, SACRED MONKEY OF THE HINDOOS.

is the same at the present day as it was in past times. The Hindoos allow their gardens and houses to be plundered by this shameless marauder without attempting any defence, and they look with an evil eye upon any one who dares to drive away their god. Another monkey (*Macacus Rhesus*) enjoys similar consideration, and in the neighbourhood of Bindrabun (monkey forest) there are more than a hundred well-kept gardens, within which every kind of fruit is cultivated for the sole use and delectation of this monkey. The gardens are kept up by the chiefs as a special mark of faith, which procures for them the respect of the native people.

This monkey worship is one of the strangest aberrations of the human mind; far less intelligible than the deification of the elephant and the bull, both of which animals are also ranked among the deities of India. From Bangkok, the city of the wild olive trees, *Bastian* relates the honours paid to the white elephant. "The white elephant which I had seen in the palace on my arrival," he writes, "was not a true specimen, some of the distinguishing points being absent in him, and he was only called Xang Pralat, or the wonderful elephant. Great, accordingly, was the joy when, a few months later, the intelligence was received that in the forests of the north a true descendant of the sacred elephant god had been discovered and captured. The king travelled several days' journey to meet him, and on his arrival in Bangkok a richly gilt platform was erected before the palace gates. Standing upon this platform, the elephant, waited upon by kneeling princes and nobles, was exhibited for many days before the eyes of the rejoicing people. Booths and shows of every kind were erected in the public square, and the whole city joined in the festivities. Above the elephant, draped in his golden housings, swinging to and fro beneath a white canopy, was a carpeted seat erected for the king, who was carried in a kind of litter, with a silver footstool. Gold and silver trees were set up in token of homage. The principal rôle in the ceremony was played by the younger brother of the king, who as chief officer of the sacred elephant, had to attend upon all its wants." The lucky mortal who is fortunate enough to discover a white elephant is raised to the rank of a noble, and receives as much land as the space across which the voice of an elephant can be heard, holding his new estate free of all tax and tribute. As soon as the news of the welcome event is brought to the capital, the governor of the province in which the elephant has been discovered receives the command to open a broad, convenient path through the forest, so that the sacred animal may be brought on its way without trouble, and embarked for the capital. When it has reached the palace, it receives its own separate establishment and courtiers, with servants to hold the parachute over it when it walks abroad, and a physician to take charge of its health. A number of slaves are constantly employed in cutting down fresh grass, and the table of the sacred guest is well provided with cakes, bananas, and sugar-cane, served in costly vessels. It is by no means necessary for a "white" elephant to be white. A few white or pale red patches are quite sufficient to make it as a white elephant, or true incarnation of Buddha. The bull is also held in high esteem among the Indian gods; an idolatry not specially characteristic of the country, for had not even the highly civilized people of Egypt their sacred bull Apis?

The wild oxen of India are the gayal (*Bos frontalis*), the ox of the jungle (*Bos gaurus*), the banteng (*Bos banteng*), the zebu (*Bos zebu*), the buffalo (*Anoa depressicornis*), the wild buffalo (*Bos bubalus*), the arna (*Bos arni*), and the kerabau (*Bos kerabau*), with many other varieties of the same species. The gayal is found in the forests of the mountain regions of the north and north-east of Bengal, between that country and Aracan. It is a true mountain ox, and is looked upon as sacred by the Hindoos, who do not venture to kill it; but when they desire to make an offering to the gods, they drive it into the pastures of the sacred grove. The ox of the jungle is found in all the large forests of Hindustan, especially those of the south. His rule in some of the old primeval forests is so supreme, that even the tiger and the bear flee before him. The banteng, or Sunda ox, inhabits the wooded hills of Java, Borneo, and Sumatra; it is a magnificent animal, pronounced by some naturalists to be the finest of all the varieties of wild oxen. Better known than the above-named kinds is the zebu, or humped ox, which owes its name to a fleshy hump upon its withers. It lives wild in many of the Indian forests, even in those frequented by tigers; and yet it is thought that these wild oxen are only the descendants of domestic animals escaped from their owners, who have regained their indepêndence, and the true ancestor from which the zebu race have descended is yet to be discovered. It is possible that the gayal or the gaur has more connection with the ancestry of the zebu than was at one time believed, for there has no sufficient answer been given to the question, why, in a country like India and Southern Asia, where there are so many kinds of wild oxen, the primitive father of the race should have died out. In any case the zebu, which is also found in Madagascar, and a great part of Africa, can boast of a high antiquity, judging from the bones of fossil zebus which have been discovered in India.

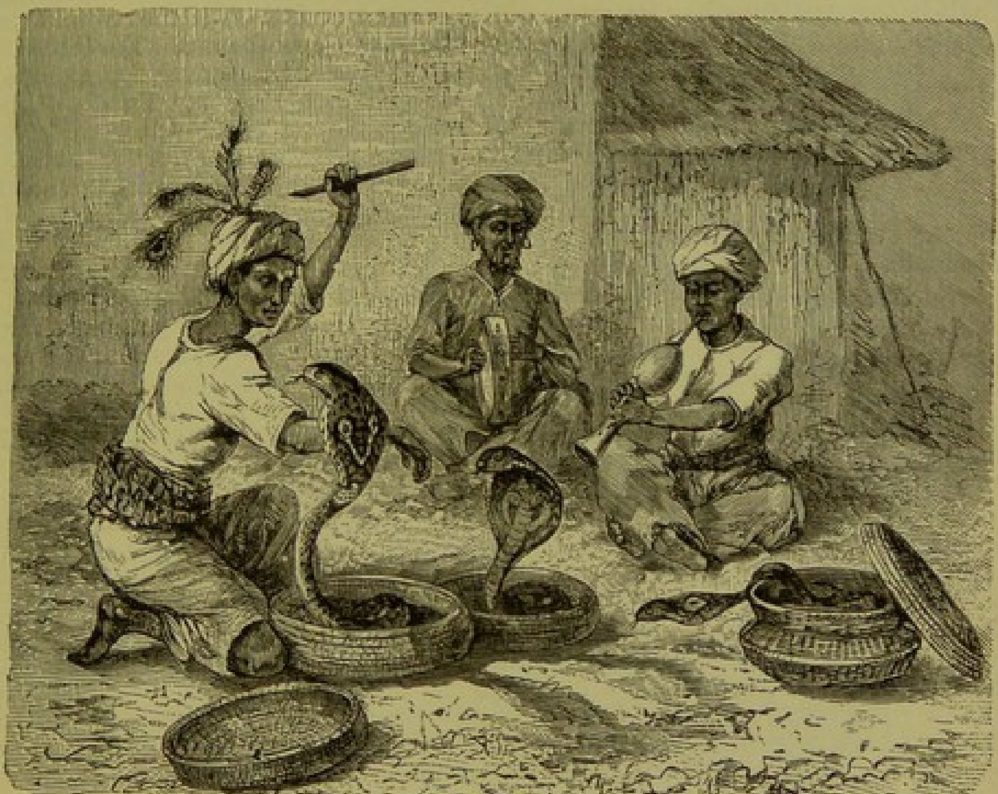
All these different oxen can be tamed with comparative ease, and they then assume the character of domestic animals—indeed, the zebu is the commonest domestic ox in the greater part of India; and yet, with the exception of the zebu, they have had little or no connection with the breeding of the European oxen. The obscurity which envelopes the origin of this useful animal, which has been for so many ages the servant of mankind, is almost as deep as that which rests upon the ancestry of our own oxen. It is now generally admitted by naturalists that the oxen found in the three continents of the Old World, and which seemed to have been tamed and brought into the service of men at about the same period, are not the descendants of one common ancestor, but owe their origin to different races; but the most careful examination of the bones of extinct animals has not enabled the naturalist to refer with any certainty the separate varieties of oxen to their respective ancestors. It is true that wild oxen are still domesticated in the present day, or used to improve the breed of domestic animals; but the times in which men first bound the wild ox, or, which is more probable, formed a herd of young ones stolen from the forests, lies far away in the mythical and legendary ages of prehistoric days. The earliest national records make mention of tame herds of oxen; they are represented on the most ancient monuments, which serve as the landmarks of primitive civilization, and their fossil bones are dug up from the muddy soil round the pale-structures of past ages.

The European ox is thought to be descended in part from the wild primitive ox or urus (*Bos primigenus*), a mighty creature with immense horns, which was hunted in many places as late as the sixteenth century of the Christian era. The beautiful wild cattle of the Scotch parks, which are allowed to breed and thrive in the interest of science, are descendants of the urus. It is of slight importance to decide whether these were originally wild, or whether they were first tamed, and have since relapsed into a wild condition. The fossil remains of the wild urus and of the primitive oxen which were tamed by our ancestors, are found scattered through every part of Europe. At the present day horned cattle descended from the *Bos primigenus* are found in Russia, Roumania, Hungary, Italy, Spain, and Portugal. The Egyptian ox of modern times is the descendant of the zebu, or humped ox. The fossil sculls of the apis bull found at Memphis corresponds exactly with those of the humped oxen of Sennar. The traveller journeying from Lower Egypt up the Nile, through Nubia and Dongola to Sennar, sees the tame Egyptian ox gradually transformed to the true humped ox of the interior of Africa, and the latter species alone is found at South Dongola and in the Bahuda steppes. But the explanation of the fact, that the strong humped ox of Sennar, brought over to Nubia and Egypt, and often crossed with other breeds, has degenerated into the long-legged, slender, antelope-shaped ox of Egypt, and has lost even its distinguishing hump, must be found mainly in the influence of climate, the different way of life, and the poor food which the Nubian owner and the Egyptian fellah are able to give it.

The link between the true ox and the buffalo is found in an animal whose home is apparently restricted to Celebes, and of whose wild life little or nothing is known. Much more familiar is the Indian buffalo (*Bos bubalus*). This animal inhabits the greater part of Hindustan and Ceylon, and is probably distributed through Further India and the south of Asia. The *bubalus*, and not the Caffre buffalo (*Bos caffer*), is the primitive ancestor of the common buffalo met with in India, Persia, Asiatic Turkey, Roumania, Serbia, Hungary, and Italy; and was first brought from Asia, in historic times, to Egypt and the European countries named above, where the tracts of marshy and grassy land favoured its existence. A second wild buffalo of India is the arna, with its colossal semicircular horns bent downward, the primitive ancestor of the last to be mentioned wild ox, the kerabau, which is found in the Sunda Islands, partly wild and partly domesticated.

"When the peacock screams, the tiger is near," says the Javanese proverb, and it is really singular how the movements of the peacock in India foretell the presence of the dreaded animal. Peacocks of every variety abound in all parts of India. Their favourite place of abode is the well-watered forest, with dense undergrowth and a high growth of trees. In these woods dwells the ancestor of this most beautiful ornament of our parks, the *Pavo cristatus*. The birds are generally found in numbers of forty or fifty, but they have been seen at times in flocks of more than a thousand birds. It is by no means easy of capture, and escapes from its pursuers, not so much by flight as by running and finding a ready shelter in the forests. The shyest and most difficult bird to approach is the argus pheasant, or more properly the argus peacock (*Argus giganteus*). The home of the great argus pheasant is Mount Ophir, situated near the centre of the Malaccas. Its cry is heard continually; and when Wallace requested an old Malayan to try to shoot one for him, the man told him that although he had shot birds in the woods for more than twenty years he had never shot a peacock, and had never seen one except in captivity. All the specimens sold in Malacca were taken in traps, and Wallace's informant, although he had not shot any, had taken many in this manner. This fact is of some importance in throwing a light upon the imperfection of our knowledge of foreign lands and their productions; for what should we have known of the argus, if it had not been a large, magnificent bird, about seventy-two inches long, whose skin was sought for museums, and its tail feathers for ornament? As a proof of the fragmentary and imperfect state of our knowledge, we may mention Wallace's remarks upon his collection of butterflies. He was walking one afternoon through the forest, when he saw upon the ground a large beautiful butterfly, of a species quite unknown to him. He tried in vain to capture it, and as the traveller hoped to capture it at the same place on the following day he went with his net, and this time he was successful. It was a perfectly new specimen (*Nymphalis calydonia*), of which a second variety was brought only twelve years later from the north-west of Borneo to England; and yet Wallace alone, during his eight years' journey in the Malayan archipelago, caught 110,000 insects, among which were 13,100 butterflies.

The cobra di capello, the hooded snake of the Portuguese, the spectacled snake of the

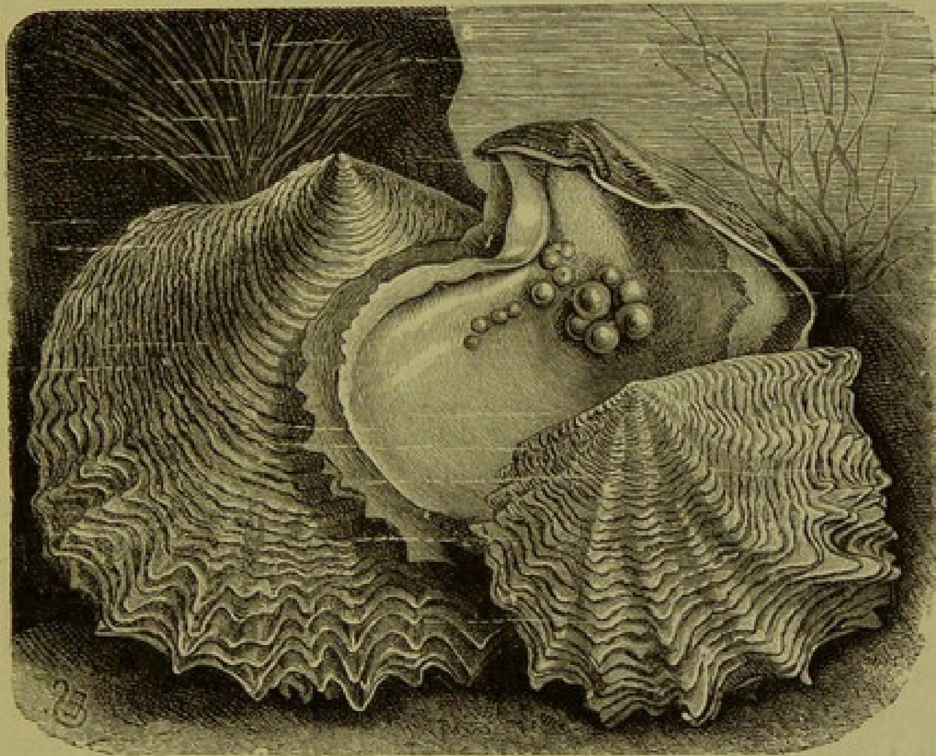


INDIAN SNAKE CHARMERS.

Indians (*Naja tripudians*), is a snake of about sixty to seventy inches in length, and of a shimmering sulphurous yellow, shading off into an ashy blue. Upon its neck is a mark resembling a pair of spectacles. The snake is found in every part of the country, and has been classed in about ten different varieties. A singular characteristic of the cobra, and one which is also possessed by the Egyptian haje, is the power of expanding the neck by a lateral movement of the first eight ribs, while the front part of the body is held stiff and erect. In this position it keeps its head invariably horizontally, so that it looks as if it wore a large round hat, if seen from behind, while in front the neck looks like a shield. Whoever has once seen the cobra, when irritated by the appearance of an enemy, raise erect the third part of its formidable length, expand its neck to a circular shield, and in this majestic attitude advance sometimes slowly, sometimes with great swiftness, to the attack, understands the fascination of horror and repulsion which it excites. Writhing along toward the object of its wrath, immovable as a column of coloured marble in front, while every muscle of its tail is excited to the uttermost, it is a striking image of baleful power. The cobra is the snake of the jugglers, and its peculiarities are often used as a means of deluding the uninitiated. "At about six o'clock in the morning," says Rondel, in his description of the performance of an Indian snake charmer on board a ship, "the juggler came on board, poorly clad, but wearing a turban adorned with three peacock's feathers. In his baskets he carried necklaces, annulettes, etc., and in a flat basket lay a cobra di capello. He established himself on the fore deck, we sat aft on several benches, and the men made a circle round. The basket was set down, and the lid removed, so that we saw the snake lying curled up at the bottom of the basket. The juggler squatted down at a little distance from it, and began to play upon a clarionette a long-drawn, plaintive, monotonous air. The snake moved, raised itself a little, and at last erected its head, and seemed to be sitting upon the few coils of its tail still within the basket. After a little while it grew restless, seemed to examine the place where it was, moved to and fro, expanded its shield, snorted rather than hissed, darted its tongue to and fro, and made several springs at the juggler, as if it meant to bite him. At the same time it leapt up and down with rather awkward springs. The more it moved, the wider it expanded its shield. The juggler kept his eyes fixed immoveably upon the snake, and looked at it with a strange fixity. After about ten or twelve minutes, the cobra became less excited, gradually calming down and rocking itself to and fro, as if sensible of the effect of the juggler's soothing music. The whole time, however, its tongue was darting to and fro with indescribable rapidity. More and more distinctly its movements conveyed the idea of of a half-intoxicated stupor. Its eyes, which seemed at first as if they would annihilate the musician, gradually gazed at him as if sightless and spell-bound. The Hindu rapidly availed himself of this moment of trance to approach the snake; advancing slowly, without interrupting his music, he pressed first his nose and then his tongue upon the serpent's head. The contact only lasted a moment, after which the snake recovered itself, and darted with concentrated fury at the juggler, who retreated in visible terror from its reach. When the man had finished playing, one of the ship's officers came up and wanted to see how the Indian pressed his lips upon the scaly head of the snake. The poor creature began his droning incantation over again, and fixed his glassy eyes once more upon the cobra. His efforts were fruitless. The snake appeared to be in a state of the wildest excitement. Nothing had any effect upon it. It tried to leave the basket, and the lid was obliged to be put on. We began to doubt that the Indian's terror is justified, and that the poisonous fang of the serpent had not been removed. We asked the man to let the snake bite two fowls, and promised him compensation for the loss. He took out a black hen, and held it to the snake. The cobra raised itself up, looked at the fowl, bit it, and let it go. The bird was loosed, and flew away in terrror. Six minutes after (I had my watch in my hand) it fell down, stretched out its legs, and died. A second fowl was given to the snake, who bit it twice, and it died in eight minutes." It is certain that many a poor juggler falls a victim to his conjuring tricks; but that others, who rely upon the greater credulity of their audience, remove the poisonous fangs from their snake before their performances. Such is undoubtedly the case with all the serpents which the conjurors twist round their arms or the neck. The cobra is the only snake exhibited by these snake-charmers.

Among the worst plagues of India are the leeches, which are found in great numbers in the grass, on the trees, or under leaves and stones. They are very quick in their movements, and scent the approach of a human being or an animal from a long distance. As soon as they perceive their victim they assemble from all quarters, and rush upon their prey. The loss of blood is not noticed at first. After a few hours they are satisfied, and drop off of themselves. "The natives who accompanied us," says Schmarda, "rubbed or smeared the wounds with lime, which they carried with them in their betel box, or with saliva mixed with lime and betel. I well understood the violent inflammation which set in afterward, and no longer wondered at the sores and gatherings on the feet of the natives. What is particularly unpleasant is, that the leeches prefer to attack the same place which has been bitten before, and are attracted by the heated and inflamed skin. We suffered less on the march than in the intervals of repose, and the first in the ranks escaped best; for when once the leeches scent their prey, they attack each new-comer with renewed vigour. In spite of all our care, we felt them now on our neck, now in our hair or on our arms; for they not only lurk in the grass, but hide upon the trees, whence they let themselves fall upon the traveller passing by."

The west coast of Ceylon, and the opposite shores of India are famous for the pearl fishery carried on in the waters adjoining. The principal centre of the diving operations is near the barren and desolate coast of Aripo, in Ceylon, where the pitiless glare of the sun scorches and consumes all which lies exposed to its fierce heat, as far as the eye can see. Parched and shrivelled leaves hang from the bare shrubs, and nothing but prickly shrub relieves the bare monotony of burning sand. The beasts seek vainly for shelter, but there is not a hand's breadth of shadow, and the trembling vapour over the sand and the sea throws back the burning heat of the sky. From the hot sand peep forth the whitened bones of divers who have sacrificed their lives to the desire of gold and treasure. The only adornment of this inhospitable place is a palace built since the occupation of the country by the English. It is a Doric building of freestone, covered with stucco made from the powdered oyster shells, and is surrounded by a wretched plantation. This desolate place suddenly becomes a scene of the liveliest animation, when the boats of the divers make their appearance, and, at the call of the government, thousands upon thousands of natives flock to the pearl fishery, from every part of Hindustan. The shore from Candatchy onward is covered as if by magic with broad streets, lined by rows of huts made of bamboo and areca stakes, and covered with palm leaves, straw mats, or gay-coloured woollen stuffs. The curious manners and customs of Hindoo life are brought together in this small space : every caste is represented. Priests, sectaries of every kind, hasten to the place ; jugglers and dancing girls amuse the crowd of idlers. Every morning, while these festivities are going on on land, about two hundred boats put out to sea, each of them having on board two divers, two assistants, and a soldier with loaded gun. The latter is there to see that no shell is rifled of its treasure before it reaches the land. As soon as this little fleet has reached its destination, a spot about a mile from the shore, the work of the day begins. To facilitate the descent of the divers to the bottom of the sea, which is from sixty to sixty-seven feet deep at this place, a long rope is wound over a roller, which is hung out over the boat's side from a cross beam



PEARL SHELL (*Avicula meleagrina*). One-third natural size.

attached to the mast. A stone weighing from 200 to 300 pounds is fastened to the end of the rope. The stone is lowered from the boat, and the diver, who is only fastened to the boat by a rope, carrying his basket and standing upon the stone, gives the signal for the descent. Weighted by the stone, he sinks speedily to the bottom ; the stone is drawn up, while the diver, clinging with his left hand to the rocks or seaweed, gathers as many shells as he can with his right hand, and puts them into his basket. If he lets go his hold of the weed, he darts to the surface ; his assistant draws him into the boat, while another man hauls in the basket. The second diver is then sent down into the water, and so it goes on until four o'clock in the afternoon, when all the boats return to Aripo with their cargoes. At the end of each day's fishing, the diver who has remained longest under water receives a special reward. The average length of time is from fifty-three to fifty-seven seconds. The noise and bustle accompanying the proceedings is so great that it scares away the sharks, and many fishing expeditions are brought to a close without any attack having been made by the dreaded creatures. The shells are generally sold to the highest bidder, or delivered to the government warehouse. The latter is a square yard, surrounded by very high walls, the floor of which is intersected by many small trenches. The shells which are not sold are placed in these trenches, and a stream of running water is kept perpetually flowing over them. As soon as the pearl shells are brought to land, they are divided into little heaps, and sold by auction. This is an amusing kind of lottery, where it is very possible to pay about fifty shillings for a great heap of shells, and not find a single pearl, and where sometimes a poor soldier, who has given a few pence for half a dozen shells, discovers a pearl of such great value, that he is able, not only to purchase his discharge, but to live free from care for the remainder of his days. In former times the government did not allow the shells to be put up to auction, but had them stored and examined by persons appointed for the purpose; but in spite of every precaution, these officials always succeeded in swallowing a number of the costliest pearls. At the present time, the shells which are not purchased are placed in the grooves mentioned above; and when they have rotted, the shells open of themselves, and the pearls fall into the grooves, and are washed down by the water into gauze bags placed to receive them. By the time the fishing season is half over, the place is a den of pestilential fevers. The mussels, which are soon rotted by the hot sun, spread abroad an indescribably offensive stench, which soon occasions the outbreak of dysentery, fevers, and other diseases, which are the constant accompaniments of miasma, dirt, and heat. When there are no more shells to be obtained, and every one is beginning to weary of the work and its attendant dangers, Aripo is gradually abandoned by its inhabitants; the shore becomes silent and desolate as before, and is given over to the troops, who are not allowed to leave until the last shell in the storehouse has putrefied.

The Islands of the Malayan Archipelago.

Situated close to the equator, and surrounded by a wide expanse of ocean, we cannot wonder that the islands of the Malayan archipelago are covered from base to summit with luxuriant vegetation. With the exception of a few small, unimportant patches, where the effects of former civilization or accidental fire have interfered with the natural order of things, Sumatra New Guinea, Borneo, the Philippines, and the Moluccas, as well as the, uncivilized portions of Java and Celebes, are all richly wooded lands. The island of Timor, with its surrounding cluster of islets, must be owned to be an exception to the rule. There are absolutely no forests found upon it such as those seen upon the other islands; and the same characteristic, though in a slighter degree, is observed in Flores, Sumbava, Lombok, and Bali. In Timor, the eucalyptus, the typical tree of the Australian flora, is frequently met with; sandal-wood, acacias, and other kinds are also found, though not in such great abundance. These plants are scattered more or less thickly over the country, but never in such a way as to deserve the name of forests. The less fertile hills are covered with coarse and scanty grasses, interspersed with luxuriant herbage where the soil is more humid. On the islands between Timor and Java are dense woods of thorn-bearing and prickly trees, which seldom attain to any great height; and, owing to the drought which prevails at certain seasons of the year, lose almost all their leaves, so that the ground beneath them becomes dry and arid, and presents a striking contrast to the dank, gloomy, evergreen forests of the other islands. This special character, which is shewn also, though less strongly, by the southern peninsula of Celebes and the east end of Java, is caused by the close proximity of Australia. The south-east monsoon, blowing from April to October, attains, as it passes over Australia, a high degree of heat and dryness, well calculated to cause the vegetation of the islands over which it blows to resemble that of Australia. A little farther eastward, the islands of Timor-Laut and Ke possess a moist climate, caused by the south-east wind on its way from the Torres Straits and the damp forests of New Guinea. Thanks to this wind, these two rocky islands are covered with verdure to their highest peaks. Farther westward, where the same dry winds pass over a much wide expanse of ocean, and have time to absorb a quantity of moisture, we fin that the humidity of the climate increases from east to west, until in Batavia, which is situated in the extreme west, more or less rain falls through the year, and the mountains are clothed with vegetation of indescribable beauty and luxuriance.

We find, upon examining the animal life of these countries, that the elephant and the tapir of Sumatra and Borneo, the rhinoceros of Sumatra, and the kindred variety of Java, the wild ox of Borneo, and also the species which was for many years considered to be peculiar to Java, are all found in one or the other part of Southern Asia, and especially in Malacca. Now none of these animals could possibly have crossed the arms of sea which separate the islands one from another; and their presence shews that there must have been a connection between the islands and the continent since the different species were created. Smaller mammals are common to the islands and the mainland; but the great physical changes by which the islands were torn away from the continent must have been the cause of the extinction of some of the different species upon particular islands. A similar lesson is taught by the distribution of birds. It is a singular fact, that Java possesses many birds which are never seen in Sumatra, although the islands are but sixty miles apart. Java, indeed, has more birds and insects peculiar to itself than either Sumatra or Borneo, from which we infer that it was separated from the mainland at an earlier period than the other islands. Borneo stands second in the possession of special organic forms, while almost all the animal life of Sumatra is identical with that of the Malaccas; and the sea which flows between these islands and the continent of Asia is everywhere less than 295 feet in depth. The Philippine Islands are surrounded by a greater depth of ocean, and, although they correspond in many particulars with Asia and the above-named islands, yet are shewn by a few peculiar distinctions to have been separated from the mainland at an earlier period. If we turn our attention to the other parts of the archipelago, we find that all the islands of Celebes and Lombok eastward have as great a resemblance to Australia and New Guinea as the western islands have to Asia. It is well known that the natural productions of Australia differ more widely from those of Asia than those of the four continents, Asia, Africa, America, and Europe, differ among themselves. Indeed, Australia stands alone; it has neither apes, nor cats, nor wolves, neither bears nor hyænas; it has no stags, no antelopes, no sheep or oxen, no elephants, horses, squirrels, or rabbits—none, in short, of the well-known types of quadrupeds which are found in every other part of the earth, if not living, at least as fossil remains. Instead of these types, it has its marsupials, kangaroos, and opossums, the wombat, and the duck-bill, or water-mole. Its birds are equally characteristic. It has no woodpeckers or pheasants, birds which are found in every other division of the globe; but in place of these it has the mound-making brush turkeys, honeysuckers, cockatoos, and brush-tongued lories.

All these striking features are also peculiar to those islands which may be termed the Austral-Malayan division of the archipelago; namely, Celebes, Lombok, and the islands eastward of the latter. The great contrast between the two divisions of the archipelago, the Indo-Malayan and Austral-Malayan, is never more clearly defined than in crossing from Bali and Lombok. At Bali we have wattle-birds, fruit thrushes, and woodpeckers, all of which we lose on our arrival in Lombok, where we are met by numbers of cockatoos, honeysuckers, and brush turkeys, the latter kinds being unknown at Bali or any of the western islands. And yet the arm of the sea is only a few miles in width; so that a two hours' journey takes us from one great division of the earth to another, which is more essentially different from it than Europe is from North America. Travelling from Java or Borneo to Celebes or the Moluccas, we find the contrast still more striking. The forests of Borneo and Java are full of different kinds of monkeys, wild cats, stags, civet cats, and otters; and one is continually meeting with new varieties of squirrels. In the Moluccas and Celebes these animals are not found; almost the only mammal here seems to be the phalanger, an animal with a prehensile tail; indeed, the only animals common to all the islands appear to be the wild pigs, since the stags now found in Celebes and the Moluccas are probably only of recent importation. The principal kinds of birds found in the western islands are woodpeckers, wattle-birds, trogons, and fruit-and-leaf thrushes; they are seen every day, and form the principal ornithological features of the country. On the eastern islands, again, they are altogether unknown, and their places are filled by honeysuckers and small lories; so that the naturalist finds himself carried into a new world, and can hardly realize that in the short space of a few days, and without having ever gone out of sight of land, he has come from one great zoological region to another. The conclusion to be drawn from these facts is indisputably this, that all the islands eastward of Java and Borneo belong essentially to a former Australian or Pacific continent, of which they formed a part. It must also be insisted upon, and this is a very interesting point of view with reference to the theories of the dependence of separate forms of life upon outward circumstances, that this division of the archipelago, characterised by such striking contrasts of natural productions, by no means corresponds to the geological or climatic division of its surface. A great volcanic chain runs through both parts, but seems to have exerted no influence towards causing any likeness between their natural productions. Borneo resembles New Guinea, not only in its immense extent, and in the absence of volcanoes, but also in the variety and richness of its geological structure, the uniformity of its climate, and the general character of the vegetation which covers its surface. The Moluccas form a counterpart to the Philippines in their geological structure, their extreme fertility, their luxuriant forests, and frequent earthquakes; and Bali and the east end of Java have almost as dry a climate and as parched a soil as Timor. And yet these islands, which seem to have been constructed on one pattern, as it were, subjected to the same climate, and washed by the same waters, present the greatest possible contrast with reference to their fauna. Nowhere else does the old doctrine, that the difference or similarity of the various living organisms found in certain countries owe their origin to a corresponding difference or similarity in their geological structure or physical peculiarities, meet with so direct and unqualified a contradiction. Borneo and New Guinea, which resemble each other as closely as two distinct countries can do, are as wide asunder as the poles, zoologically speaking; while Australia, with its dry winds, open plains, stony deserts, and more temperate climate, possesses birds and quadrupeds very nearly related to those which inhabit the hot, moist, luxuriant forests that clothe the plains and mountains of New Guinea.

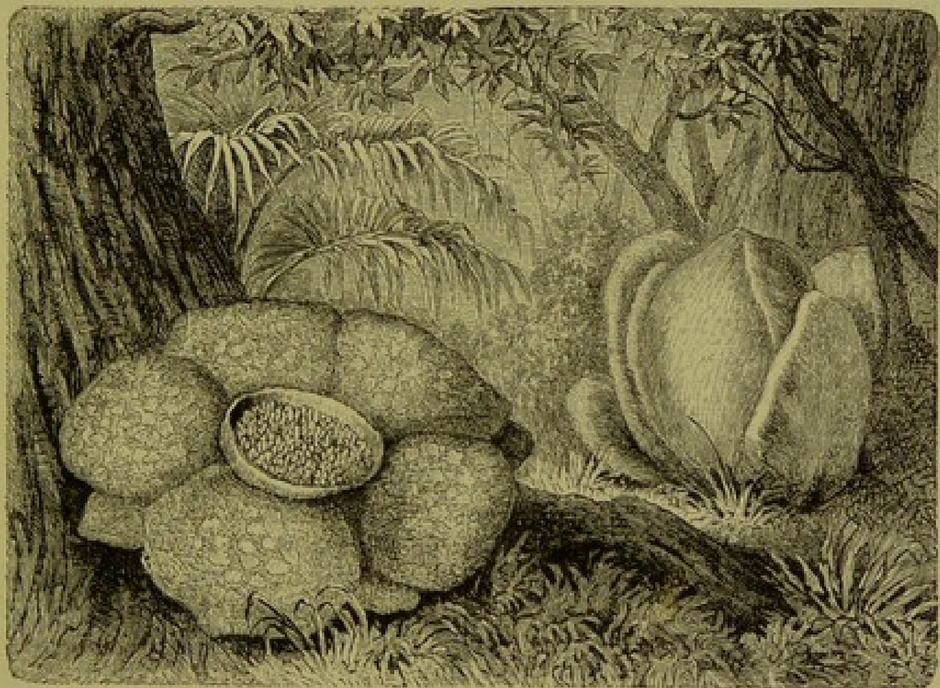
In order to explain the method by which this contrast is effected, we will endeavour to describe the results which would follow from the approximation by natural means of two strongly contrasting divisions of the earth. It must be confessed that there are no other divisions so radically different in their productions as Asia and Australia; but the difference existing between Africa and South America is also very great, and will perhaps be sufficient for our purpose. Let us suppose that the bed of the Atlantic Ocean were slowly uplifted in such a manner that the two continents were extended over the surface of the water, until they were separated from each other by an arm of the sea only a few hundred miles in width. At the same time we will suppose that islands should arise within this arm of the sea, and that the subterranean forces should not only vary in intensity, but also change their principal centre of attack. What would be the result? A succession of islands would at one time be joined together, and at another violently torn asunder; certain islands would alternately be connected with one or other side of the narrow channel, and detached from it again. And if, finally, after a prolonged period of such activity, we saw the Atlantic channel gradually filled with an irregular island archipelago, we should not be able, from its form and distribution, to discover any signs by which we should learn which parts had been joined to America, and which to Africa; but the animals and plants upon the island would certainly reveal, at any rate in part, the secret of their former history. For on the one side we have Africa with its baboons, lions, elephants, buffaloes, and giraffes; on the other side, South America, with its spider-monkeys, pumas, tapirs, anteaters, and sloths; while among birds, the hornbill, turacos (*corythaix*), orioles, and honeysuckers of Africa would contrast in the most marked degree with the toucans, macaws, chatterers, and humming-birds of America. Now we should be certain to find upon those islands which had formerly made a part of South America, toucans, humming-birds, and some of the quadrupeds peculiar to America; while upon the islands separated from Africa we should be equally sure of finding hornbills, orioles, and honeysuckers. A few of the newly made islands would probably have had a transient connection with both continents at different times, and would therefore present in their living forms an appearance of the blended life of both America and Africa. Now in the Malayan archipelago we have an exactly parallel case to the one just stated; Sumatra, Borneo, and Java belonged to Asia, New Guinea to Australia, Celebes and the Philippines represent the islands which possess a mixture of the fauna and flora of both continents, and the adjoining islands of Bali and Lombok furnish us with an example of the products of the continents to which they respectively belong, remaining distinct, and without any mixture whatever.

The view just stated is that of the great naturalist Wallace, and in opposition to it we are bound to mention the theory put forward by Griesbach, but admitted by its author himself to be unsupported by direct observation. Griesbach starts from a consideration of the different position occupied by plants and animals with reference to the outer world. According to their organisation, the former are most dependent upon climate, and the latter upon the vegetation which serves them for food. If the bottom of any sea is changed into a continent, its climate is decided by its geographical position, the formation of its coasts, and the form of surface. If, then, there is any exertion of creative force, the forms of vegetation will be such as suit the climate. They are, in fact, at the present moment, everywhere found in correspondence with the climate, from the Malayan archipelago to the islands of the South Seas. But if we suppose that at some former period the eastern side of the archipelago did not yet possess its mountains, and, as Wallace also supposes, was joined to Australia, the Australian climate might well extend to the archipelago; but when the subsequent upheaval of the mountain chain had produced its necessary alteration of climate, the earlier vegetation would also slowly disappear. A new flora would arise; but the fauna, which is less dependent upon climate, might preserve its original type for a longer period, and perhaps the present time is to be regarded as a period in which the Australian animal forms of New Guinea are in process of dying out, because the vegetation is no longer adapted to their nourishment. It seems indeed as if creative power were only put forth upon certain parts of the earth's surface at certain times, and that in the long pauses between each awakening of this force nature is occupied only in preserving existing forms in their struggle for existence. During the period in which the mountains and the moist climate of New Guinea were developed, there was no new creation of mammals. But in other animal classes there arose forms corresponding to the present vegetation, such as the birds of paradise, which are unknown in Australia, and which in New Guinea hover round the crests of the trees, whose foliage protects them from the midday sun.

These two conflicting theories, the former corresponding to the Darwinian theory of evolution, and the latter combating it, are quoted by us here without reservation, and principally in order to call attention to the difficulties which still beset the study of the geographical distribution of plants and animals.

SUMATRA.

The interior of the island of Sumatra, equal in extent to the Iberian peninsula, is clothed with dense forests, little known to European travellers or modern science. Herr von Rosenberg, a traveller who has described his sojourn in the Batta lands, relates that in many places the primeval forests are of such dense growth, that when his companion abandoned him he was unable to make his way through the wood as far as Lumut, although he was near enough to hear distinctly the stroke of the bells chiming the hour. A different picture is presented by Padang Lawas, a tract of land where the little fortress of Pertibie formerly stood. "We saw at our feet a monotonous level stretching out to the horizon in grassy plains of varying colour, now light, now dark, and covered with *Imperata cylindrica.* There was scarcely a sign of life to be perceived. The grass grew to a height of three or five feet, reed by reed, choking all other plant growth, although it is probably not indigenous to the place, since its home extends over all Africa and the coasts of the Mediterranean. The plain is but sparsely covered with trees, which appear here and there as a small wood or a belt enclosing a river bed or tract of marshy ground, abandoned during the dry season to the blasts of a violent scorching wind, which often rages for weeks together, until everything is burnt up, and nature seems to sink into the sleep of death. At the same time the climate is rather rough, the temperature often sinking from 95° Fahr. at noon to 62·5° at midnight. The vegetation of the Padang highlands presents many peculiarities worthy of interest. The ground moisture, which never completely fails in this district, calls into existence a grand vegetation, which strikes the imagination by its imposing magnificence. The forms of our own vegetable life sink by comparison into poverty and nothingness. High primeval forests spread their gloomy mantle over mountain and valley, and only the sheer vertical walls of cliff are bare of vegetation. Watercourses flow between precipices densely covered with low tree growth, shrubs, and other plants. Here stands a grove of wild bananas, with glossy pale-green leaves, here rise solitary small palms of *areca* or *pinang*, with their clusters of brown or yellow fruit, in another place miniature trees resembling the *ricinus* or castor-oil plant (*Horsefieldia aculeata*), with leaves as large as a hand, grass green on the upper and red on the lower side, or a *Cæsalpinia*, with long upright clusters of bloom. But beautiful as these and other plants are, they are all eclipsed by the lovely tree ferns (*Chnoophora* and *Alsophila*), which are perhaps the most graceful of all vegetable forms. When one adds to all this splendour a panorama changing at every bend of the road, bathed in the glowing light of the tropic sun, whose heat is no longer oppressive, flights of bright-plumaged birds darting to and fro across the path, and innumerable butterflies of large size and glorious colouring flying from flower to flower, or floating lazily above the silver foaming brook, one may form some idea of the wonderful scenery which realises the picture so often formed in the imagination of the untravelled reader, and so seldom found in



RAFFLESIA ARNOLDI.

fact, of the typical beauty of the tropics." The thermometer only varies from 60·8° to 80·5° Fahr. The forests are rich in costly woods, gutta-percha, caoutchouc, pepper, camphor (*Dryobalanaps camphora*), benzæ, (*styrax benzœ*), and dammargum. Sumatra would be able to supply the market with gutta-percha for a long time, even if every other supply were exhausted.

In the forests, growing upon the cissus lianas, we find the splendid *Rafflesia Arnoldi*, whose flowers exceed in size those of any other plant. Along the low creeping roots of the cissus rise a succession of rough knobs, at first about as large as a hazel nut, then swelling gradually to the size of a walnut, then to that of an apple, and finally to that of a small head of cabbage. The brown blossom then bursts through the rough hull, the petals overlying each other something like the leaves of a cabbage. At last the gigantic flower (from about twenty-four to forty inches wide) expands, the thick, pulpy, flesh-coloured petals spreading round a repulsive, corpse-like odour, and quickly decays. In the centre is a flesh-coloured case concealing the organs of germination.

Rice is the chief article of culture, but bananas and the ordinary kinds of fruit of the Sunda Islands are only found near the settlements. With the exception of the grassy plains of Padang, which we have described above, and of a few plateaus, and the forests which darken the sides of the rugged mountains, a rich fauna is met with in every part, both as regards the variety of species and the number of individuals in each.

The full-page illustration, Plate V., represents the vegetation of this part of the world. In the foreground to the left rises a group of the native East Indian sugar-cane, behind which the melon tree (*Carica papaya*) is seen. The latter is not an indigenous plant, but has been cultivated for centuries. Branchless stem, long-stalked, hand-shaped leaves, and clustering fruits, growing at the summit, are its characteristics. To the right, two pandanus trees (*Pandanus odoratissimus*), standing upon their aerial roots, as if upon stilts. Behind, near the ground, is a large fern, and in the far distance some undistinguishable giant of the woods, near to which a slender cocoa palm rears its graceful crown behind some bananas. The right of the foreground is taken up by some caladia as tall as a man, behind them stands the bread-fruit tree (*Artocarpus incisa*). To the right of the background, in the misty distance is a lofty tree, which, from its size and the division of its branches, may be the famous upas tree (*Antiaris toxicaria*).

The principal ape is the orang-outang, which is only found in marshy places in the forests along the coast, principally in those lying along the centre of the east coast, and which, owing to their difficulty of access, have seldom been trodden by a human foot. The specimens seen there by Von Rosenberg contrasted strongly, by their reddish fox-coloured skin, with their dark, rusty-looking kindred in Borneo. Long-armed apes, siamangs (*Hylobates syndachylus*), and ungkos (*H. agilis*) are also found; they inhabit the forest-clad mountains to the height of about 3,280 feet, preferring the crests of the trees which grow down the mountain slopes, and seldom alighting on the earth. On the slightest alarm they flee with bird-like swiftness down the hill, and disappear in the impenetrable darkness of the woods. They are consequently but little known, and their manner of life and division into separate classes is even yet very imperfectly described. Brehm, who has every right to be considered an authority, calls the ungko *Hylobates rafflesii*, and the *H. agilis* wow-wow, in opposition to Von Rosenberg, who spent nearly a lifetime in this island archipelago. The former distinguishes the two by the colour of the face. Sumatra contains many kinds of monkeys, among which are the *Semnopithecus*, the *Cercopithecus* and *Innuus*, the *Stenops tardigradus* and the *Tarsius spectrum*. Very remarkable, too, is the *Galeopithecus variegatus*, a bat-like animal with hairy winged skin. The flying fox (*Pteropus edulis*) is very common, living in large bands both on the coasts and in the interior of the country. There are many kinds of bats.

Among carnivora, the royal tiger takes the first place, especially in the more thinly populated districts of Padang, and the high table-land where low scrub and dense woodlands alternate with wide grassy plains. One trader in the region tells us that—

The neighbourhood of the Redoute at Pertibie was rendered so unsafe by the presence of these formidable neighbours, that no one dared to leave the shelter of his home from sunset to the break of day; so that regularly, at a few minutes after six, the entrance to the fort was closed. During Von Rosenberg's residence at Pertibie, a native walking from the fort across the market place to the village was carried off in broad daylight; the tiger sprang upon him so suddenly that there was no possibility of a rescue, although the shrieks of the unhappy man were heard for a considerable time from the adjoining thicket. The tiger of Sumatra and Java, the Java tiger, as it is called by the traders, differs in many particulars from the tigers of Bengal. Its colour is on the whole less red or rusty hued, the black stripes are narrower, darker, and closer together, less slanting in direction, and seldom shewing that sharp angle which makes the black line down the back of the Bengal tiger. The Java tiger also is smaller and stronger in proportion than that of the mainland. 'Any one would suppose, says Brehm, that such a splendidly marked animal would be seen easily, and at a distance, by the prey which it seeks. But such is not the case. Even practised hunters say that it often happens to them to overlook a tiger which is right in their path. The cause of this is that the colour of the tiger, like that of all Javanese animals, and especially of the feline tribe, corresponds in the most bewildering degree with the tints of the surrounding landscape; one has but to recall the cane forests, the grassy thickets, and the yellowish bush, which serve the tiger for a lurking place, to perceive the justice and force of this explanation.

The Malayan bear (*Ursus malayanus*) is a frequent apparition in the forests. It passes the daytime generally in caves or hollow trees, sometimes, however, making a nest of twigs and branches upon the flat stump of a low tree. Instances have been known in which, driven to bay, the bear has attacked and killed men, but they are rare. A remarkable animal, peculiar to Sumatra and Java, is the stinkard (*Midaus melliceps*). This animal, an inhabitant of the mountains, developes in certain glands a sticky fluid, which it scatters as a means of defence when attacked. The fluid has a powerful stench, resembling garlic, which can be perceived, we are told, at a distance of two miles. It is so strong, that it can poison the air of a whole village, and causes many persons, if unable to escape from it, to faint and lose consciousness.

Among rodents we must mention the squirrel and the short-tailed porcupine (*Hystrix macroura*). The pachydermata are represented by the elephant (*Elephas Sumatranus*), which must, perhaps, be classed as belonging to a different variety from the Indian elephant. It is often seen in herds of forty to fifty animals. It is possible, however, that these numbers are exaggerated; for they wander about, and seldom revisit the same pasture ground twice in succession. The natives have never tried to tame the elephant. An animal peculiar to Sumatra is the Sumatra rhinoceros (*Rhinoceros Sumatranus*), a slighter, and higher-built animal than the Indian rhinoceros; it is common in the mountains, but seldom met with, owing to its retired habits of life. Von Rosenberg never saw it in the open, though he often came across its tracks. It lives up to a height of 6,500 feet. The Indian tapir is often found in the woods near the coast. Wild boars (*Sus vittatus*) are found everywhere, except on the steep rocky mountain ledges: they roam the sea coasts to the mountains, as well in the woods as on the grassy plains. Among ruminants are the maned stag (*Cervus Hippelaphus*), the small deer (*Cervulus muntjac*), the musk deer (*Tragulus napu*), and the goat antelope (*Antilope sumatrensis*). The latter animal inhabits the loneliest mountain forests, dark, rocky ravines, or steep, inaccessible mountain slopes, and is therefore but little known; it is probably identical with the goral (*Nemorhædus goral*) of the Himalayas. The banteng (*Bos banteng*), a wild ox, not mentioned by Von Rosenberg, is said to be frequently seen on the east coasts of the island. A scaly animal (*Manis Javanica?*), the flesh of which is eaten by the natives, is very common; its favourite place of abode is the wooded mountain steeps, where it climbs the trees to find its food. Where the earth is free from rock and stone, it digs holes in the nests of ants and termites, and gets the eggs or living inhabitants on its sticky tongue, to devour them in quantities.

If the number of mammalia in these islands is so great that they can only be treated of in a very cursory manner, the number of birds is even more considerable. We are therefore obliged simply to mention those species which are either characteristic of their dwelling place, or which attract the attention even of the uninitiated, by some striking peculiarity, or beauty of colour. The bird life is, of course, more fully developed in wooded regions than in bare and open districts. Eagles—above all, the magnificent Malay eagle (*Aquila malayensis*)—hooded, fisher, and sea eagles; falcons, sparrow-hawks, and owls, represent the birds of prey. Salanganes (*Collocalia nidifica*) build their edible swallow nests in the holes of the rocky coasts. Numerous kingfishers inhabit the river banks, honeysuckers (*nectarineæ*) and thrushes the plains; and many, as for instance the nectarina lapida, are found close to the villages and towns, under the shadow of the cocoa palms. Singing birds of different kinds are very numerous; orioles, flycatchers, shrikes, and ravens animate the scenery. A bird resembling a starling (*Eulabes javanicus*) is very common in many places; it is one of those birds which most easily learn to imitate the human voice. The singing starling (*Lamprotornis cantor*) generally lives in the crests of the sugar palm (*Arenga saccharifera*). One of the commonest birds in the grassy wilderness of Padang Lawas is the yellow-headed weaver (*Ploceus hypoxanthus*), whose large pouch-shaped nest is often seen hanging from the branches of the trees. There are several varieties of finches or *amadinæ*. The rice fowl (*Amadina oryzivora*), which belongs to this class, and which is now often found in the neighbourhood of Padang, is the descendant of some birds brought over from Java. There are numerous rhinoceros hornbills (*Buceros rhinoceros*), the flapping of whose wings, as they support the heavy body, is so loud, that Wallace tells us it can be heard for nearly three-quarters of a mile. The *berenicornis* is an African variety of the hornbill, but is now found in Sumatra. Among the most beautiful parrots are the *Psittacula incerta* and the *Corryllis galgulus*; the latter, or blue-crowned parrot, is often seen in cages, where it sleeps, after the fashion of the bat tribe, by hooking itself up by the feet, and hanging head downwards. The *bucco*, or wattle-bird, has a cry resembling "took-took-took," which lasts for several minutes. The *Psilopogon* is a curious kind of wattle-bird, once thought to be peculiar to Sumatra, but now found in Borneo and Malacca. Woodpeckers, pigeons, parrot-pigeons (*Treron*), turtle-doves, ruff-pigeons (*Calœnas nicobaria*), pheasants (*Euplocomus ignitus*), partridges, and quails, are frequent. We must also notice the bankiva (*Gallus bankiva*), which has the best-grounded claim to be considered the primitive ancestor of our domestic fowl, and the splendid argus pheasant (*Argus giganteus*). The latter bird is not rare, but it is so shy, and clever in evading pursuit, running swiftly into the densest part of the woods, that it is impossible to approach it. When Wallace asked an old Malayan to shoot one of these birds for him, the man told him that, although he had been a sportsman for twenty years, he had never shot one or even seen one in its natural state. All that he had seen were in captivity; those sold in Malacca are caught in traps, and such was probably the case with the living specimens seen by Von Rosenberg in Padang, and bought by him for about one shilling and sevenpence. We conclude our list of birds with the heron, snipe, and sea swallow. The remaining animals present no special claims to interest. Domestic animals are represented by buffaloes, horses, dogs, cats, goats, fowls, and pigs. The latter are either young pigs captured from the wild pig (*Sus vittatus?*), or their descendants.

The group of islands to the west of Sumatra has no mammals, and

AMERICAN BISONS AND PRAIRIE DOGS.

perhaps no birds which are not also to be found in Sumatra, while all the larger mammals and a number of birds are wanting. No tiger, elephant, rhinoceros, or bear, renders the woods unsafe; no tapir rushes through the marshy bush; and the mysterious silence of the forest is nowhere broken by the penetrating howling of the monkey. But the *Palacarnis javanicus*, a member of the parrot tribe, is found in them, which has not been observed in Sumatra.

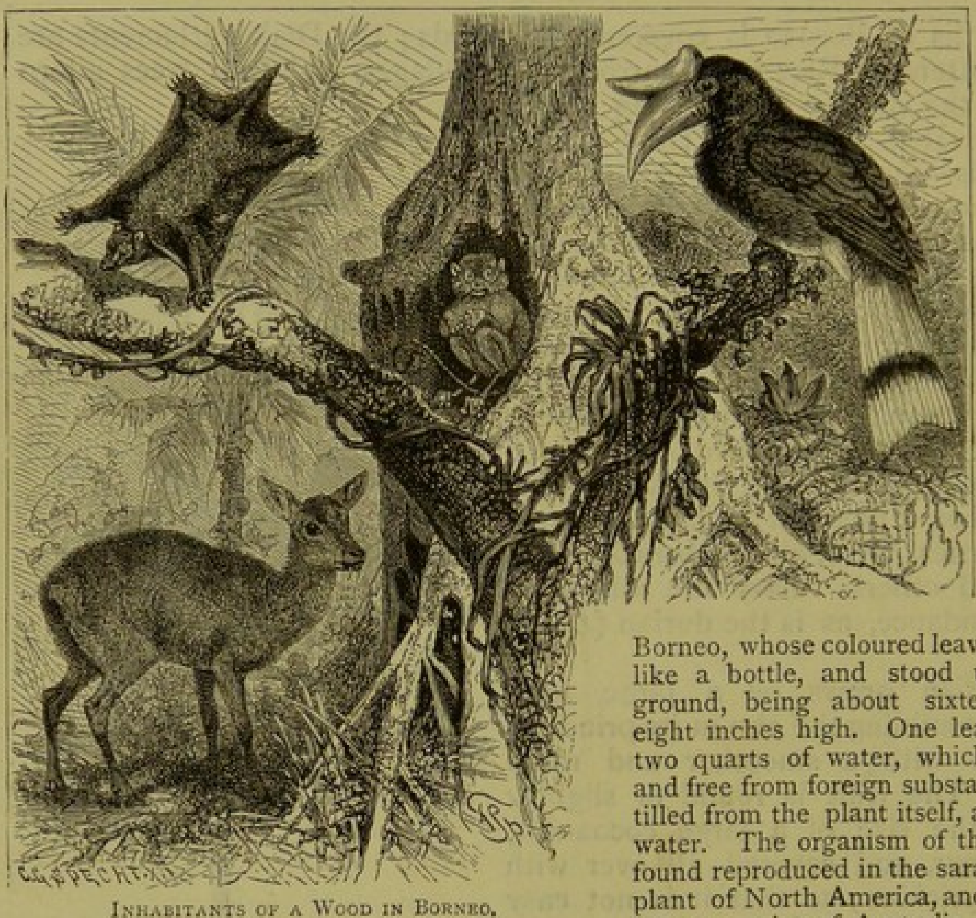
BORNEO

Nine-tenths of Borneo is covered with woods; the Diak settlements are small and scattered. Rice fields surround the villages, and fruit trees adorn the banks of the smaller rivers, along which they are cultivated. The fruit trees are of various kinds—the delicious mangustane (*Garciana mangustana*), the lansat tree (*Lansium domesticum*), resembling our Damascus plum in its thick clusters of fruit. The fruit has a sweet gelatinous pulp and a bitter kernel. The rambutan (*Nephelium lappaceum*), a tree with longish fruits, shaped like a plum, and tasting like muscatel grapes; the true or undivided-leaved bread-fruit tree, whose delicious fruit weighs twenty-five pounds, and has a pleasant favour; the sour tree gooseberries (*Averrhoa Carambola, A. Bilimbi*); and others. They are all found in great abundance, as is the durian (*Durio zibethinus*).

CAMPHOR TREE (*Dryobalanops camphora*).

The durian grows on a large, high forest tree, resembling the elm in its principal features, but with a smoother and more scaly bark. The fruit is round or slightly oval, about the size of a large cocoa-nut, green in colour, and covered all over with small sharp prickles; so that it is not easy to pick up the fallen fruit from the ground, if the stalk is broken off. It has five markings, where it can be opened and divided into five parts. Each part is filled with a pink pulp, containing two or three seeds the size of a chestnut. The pulp is the edible part, and both in flavour and composition is absolutely indescribable. A highly spiced, buttery custard, strongly flavoured with almonds, gives the best general idea of it; but to this must be added a suspicion of the flavours of cream cheese, onion sauce, brown sherry, and other incongruities. The fruit is neither sweet, nor sour, nor juicy; but the want of none of these qualities is felt; it is perfect just as it is. But unfortunately it smells so bad, especially if not perfectly fresh, that some persons can never overcome their disgust, or be persuaded to taste it. Such was the case with Wallace when he first met with it in the Malaccas; but when afterwards, in Borneo, he found a ripe fruit upon the ground, and ate it in the open air, he became at once a confirmed durian eater, a fact deserving attention, because it provides us with the means of reconciling the conflicting testimony of writers concerning the fruit. For although the natives, who possess all sorts of delicious fruits in great abundance, give the palm to the durian, and even write verses in its honour, and old Linschott, who wrote in 1599, or thereabouts says that it surpasses all other fruits in flavour, yet we find recorded in other valuable German works, that its pulp tastes unpleasantly of rotten onions, and is not eaten by foreigners.

Borneo is principally celebrated for its camphor tree (*Dryobalanops camphora*), and for its giant pitcher plants (*Nepenthes*).



INHABITANTS OF A WOOD IN BORNEO.

On the ground is the pretty Musk Deer (*Trajulus javanicus*); in the tree sits the goblin monkey (*Tarsius spectrum*); to the left are two specimens of the insectivorous *Galeopithecus volans*; to the right the large rhinocerous bird (*Buceros rhinoceros*).

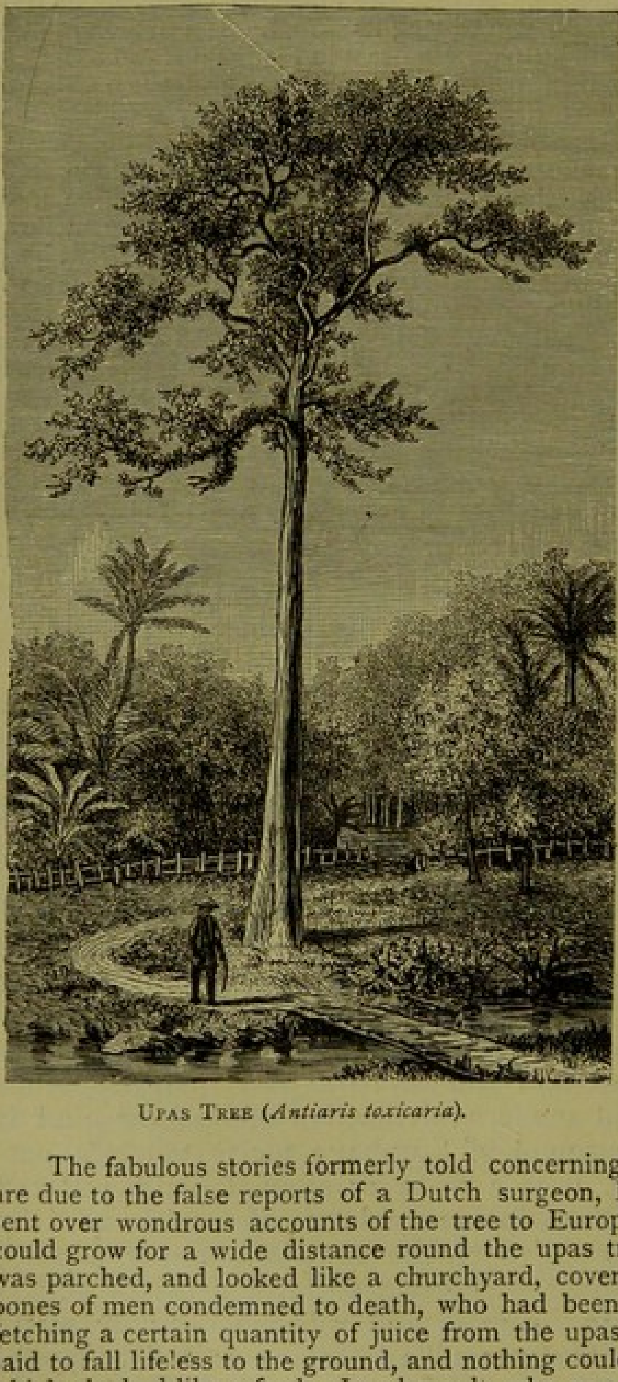
The pitcher plants are creeping plants growing along the ground or clinging to rocks. Their leaves are in the form of water flasks with a lid. They are met with in the lower wooded regions of Madagascar and New Caledonia, but Low discovered a species (*Nepenthes rajah*) in Borneo, whose coloured leaves were shaped like a bottle, and stood upright on the ground, being about sixteen to twenty-eight inches high. One leaf holds about two quarts of water, which is drinkable, and free from foreign substances; it is distilled from the plant itself, and is not rain-water. The organism of the nepenthes is found reproduced in the saracenia, a marsh plant of North America, and in the cephalotus, a native of Australia.

It would be superfluous to write in detail concerning the fauna of Borneo, since it is little more than a repetition of that of Sumatra, although lacking some important animals, namely, the siamang and the rhinoceros. The orang-outang or mias, the long-nosed monkey, and the flying frog are met with more frequently here than in Sumatra.

The orang-outang inhabits exclusively low, marshy woods. An unbroken stretch of forest of equal height is a necessity of its well-being. Such a forest is to him an open plain, in which he can move about in every direction with the same ease and agility as the Indian traverses the prairie, or the Arab crosses the desert. He goes from one tree top to another without ever descending to the earth; and it is a strange and interesting spectacle to see a mias leisurely making his way through the forest. He goes along one of the longer branches, in the half-upright position to which the singular length of his arms and the shortness of his legs restrict him, and the confusion between arms and legs is heightened by his walking on his knuckles, and not upon the flat palm. The height of a full-grown male is four feet six inches, and the width of the extended arms eight feet. The orang-outang builds himself a nest in which to sleep at night. One of these animals, wounded by Wallace, climbed to the top of an immense tree, and began at once to break off branches right and left, and to arrange them so as to build a nest. It was very interesting to see how well it chose out its place, and how quickly it moved its wounded arm in every direction to break off large branches. It did this with the greatest rapidity, laying the twigs crosswise one over the other, so that in a few minutes it had raised a mass of dense foliage which completely hid it from view. The mias seldom descends to the earth, except when, pressed by hunger, he goes to look for young juicy shoots along the coast, or seeks for water in very dry weather. In ordinary cases he finds enough in the folds of the leaves. The Dyaks told Wallace that the mias is never attacked by any animal in the forest. "The mias has no enemies: no animal dares attack him, except the crocodile and the python. It kills the crocodile merely by its own strength, standing upon it, forcing open its jaws, and tearing its throat. If a python attacks it, it seizes it with its hands, bites it, and soon kills it. No beast in the jungle is so strong as the mias." Even the presence of human beings does not seem to alarm them. "They generally stared at me for several minutes," Wallace says, "and then slowly withdrew to a neighbouring tree." They do not, as a rule, attack men; but when forced to do so, they are most dangerous opponents. The orang-outang feeds almost exclusively upon fruit, but occasionally it eats leaves, buds, and young shoots. It appears to prefer unripe fruit, especially sour and bitter-tasted ones; sometimes it only eats the small seeds of a large fruit, and always wastes and spoils more than it eats, so that there are always a great heap of fragments under the trees where it has been feeding. In the countries where the mias is chiefly hunted, the long-nosed monkey (*Nasalis larvatus*) is found. This animal is as large as a three-year-old child; it has a very long tail and a fleshy nose, longer than that of the most thick-nosed man. The flying frog (*Rhacophorans Rheinwardtii*) is about four inches long; but the webs of its feet, when fully expanded, cover about thirteen square inches. It was pointed out to Wallace as an animal which its captor had seen coming down in a slanting direction from a high tree, as if flying. The naturalist considers it to be deserving of the greatest attention, as shewing how the adaptability of the toes (which are already modified by the frog for swimming and climbing) might be turned to account by a kindred species, so as to enable them to fly through the air like a flying lizard.

JAVA.

Java is indisputably the pearl of the Sunda Islands, perhaps of all the islands in the world; it is certainly the most fertile, productive, and populous island of the tropics. Its whole surface presents a magnificent alternation of mountain, woodland, and landscape scenery; for the excessive moisture and the tropical heat of the climate clothe the mountains (which contain thirty-eight volcanoes) from base to crown with a luxuriant plant growth; while the lower slopes are covered with forests and plantations. The animal world, especially in its birds and insects, is very rich and diversified, and contains many exclusive, though small forms, which are met with nowhere else in the world. Besides these distinctions, Java has a history, and in the eastern districts it contains antiquities of great interest—ruins of great cities in places where now the tiger, the rhinoceros, and the wild ox pass their existence undisturbed. In the present day a modern civilisation of another kind is spread over the land. The neighbourhood of Surabaya, for instance, is perfectly flat, but tilled in every part; it is a delta or alluvial plain, watered by many branching streamlets. The palpable evidence of wealth, and the presence of an industrious population, give to the town a pleasing aspect; but in pushing further on, the unbroken succession of level fields of sugar-cane, rice, or indigo, fenced in with bamboo, and relieved only by white buildings and the high chimneys of the sugar mills, becomes extremely monotonous. The streets extend without a turn for more than a mile, and are fringed by dusty tamarind trees; but on the hillside, near Batavia, the terraced slopes, with their high degree of culture, can scarcely be equalled anywhere in the world. The slope of the principal valley and its separate branches are laid out in terraces; and when they are seen winding round the retreating hills, they produce the effect of a grand amphitheatre. Hundreds of thousands of acres are laid out in this way; the whole surface of the country is divided into perfectly flat, irregular fields, of the most various sizes, each one of which is raised either by a few inches or by several feet over the one below. Such an extent of culture was only made possible by the inhabitants of each village working individually and collectively under the guidance of their chiefs. This is the land for the wide-spread cultivation of coffee, tobacco, tea, maize, etc.; while the neighbouring heights are rich in rasamala, arengo palms, teak, bamboo, and orchids. The average height of the plantations is only from sixty-five to eighty-two feet, according to Junghuhn; solitary trees tower above the rest by a third or fourth their height; the rasamala (*Altingia excelsa*) is twice as high as the rest, and looks from a distance like a wood within a wood. The region of the laurels, oaks, and cinchona plants is found above this, at a height of 7,545 or 9,840 feet.



UPAS TREE (*Antiaris toxicaria*).

A certain notoriety has long been enjoyed by the Java upas, or poison tree (*Antiaris toxicaria*). It grows from sixty-five to ninety feet high, and yields a poisonous, milky juice, containing a quantity of yellowish strychnine. The juice is mixed by the Malays with several other astringent and aromatic vegetable substances, and made into a thick, dark-green mass, which has a bitter taste, and is a deadly poison. It is called upas-antiar, and was formerly used by all the Malays, as it is now by certain tribes, to poison the tips of their arrows.

The fabulous stories formerly told concerning the poisonous properties of the upas tree are due to the false reports of a Dutch surgeon, Forsch, who lived in Batavia in 1776, and sent over wondrous accounts of the tree to Europe. According to his statements, no plant could grow for a wide distance round the upas tree. "The ground beneath it and around was parched, and looked like a churchyard, covered with the skeletons of animals and the bones of men condemned to death, who had been allowed to choose between execution and fetching a certain quantity of juice from the upas tree. Birds passing over the tree were said to fall lifeless to the ground, and nothing could live near the tree except a horned snake, which clucked like a fowl. Leschenault, who was sent out in 1810 by the French Museum, visited Java, and discovered the erroneousness of these reports. He had a upas tree felled, examined it himself, classified it according to its botanical qualities, and superintended the preparation of the poison from the juice. The tissue of falsehoods woven by Forsch is not yet forgotten. Leunis has tried to explain his statements by the fact that upas trees are found growing near to the pestilential air of a deep volcanic depression about two miles in circumference, and thirty-three feet in depth, where deadly exhalations of poisonous gases, carbonic acid, and sulphuretted hydrogen, are continually rising from the ground, so that no other plant can grow near it, and the animals which fall into it are suffocated.

The wooded covering of the mountains marks the transition from a tropical to a temperate climate.

Wallace describes an ascent when the first plants of the temperate zone were met with at a height of 3,000 feet. Strawberries and violets grew there, but the former were tasteless, and the latter bore small and colourless blossoms. The composites growing on the wayside give to the foliage something of the European appearance. At between 2,000 and 5,000 feet the woods and treeless plains present an aspect of the most luxuriant tropical beauty. The abundance of noble fern trees, of fifty feet in height, mainly contributes to the general effect, for they are beyond all doubt the most marvellous and beautiful of all the forms of tropical vegetation. Some of the deep ravines, in which the larger trees have been felled, are covered with ferns from top to bottom, and where the path crosses one of these gorges the feathery crowns waving overhead and below the feet of the traveller form such a combination of picturesque beauty as is impossible to forget. The glossy foliage of the broad-leaved banana and ginger, with their singular shining leaves, and the elegant and diversified forms of the various plants allied to the bignonia and the melastomaceæ, attract attention at every turn. Filling up the spaces between the trees and the larger plants are numberless orchids, ferns, and lycopodia, which cling to every branch and stump and twig in ever-changing combinations. At the height of about 5,000 feet, a horsetail shave-grass resembling our own was seen. At 6,000 feet were many raspberries; and from that place to the summit of Pangarango, a mountain about 10,000 feet high, three different kinds of blackberries were found. Cypresses appeared at the height of 7,000 feet; the forest trees became smaller, and were covered with mosses and lichens. From this point the latter were much more widely developed; so that the fragments of rock and lava, of which the rock is composed, lay perfectly buried in a mossy covering. At the height of about 8,000 feet, European plant forms became very numerous. Different kinds of honeysuckle, St. John's wort, and guelder roses were everywhere found; and at 9,000 feet the rare and beautiful cowslip, *Primula imperialis*, was seen. This flower is sometimes more than three feet in height, and is said to grow nowhere else except on this one mountain peak. The forest trees, reduced to the dimensions of shrubs, extend right up to the edge of the old crater, but do not descend within it. Here was found a good deal of open country, with thickets of wormwood and cudweed, resembling the European kinds, but from six to nine feet high. Buttercups, violets, whortle berries, sow thistles, stitchwort, lily of the valley, white and yellow cruciferæ, plantain, and other annual grasses, are richly represented. Where there is any shrub or undergrowth, honeysuckle and St. John's wort are most abundant; while the *primula imperialis* only erects its elegant blossoms under the moist shade of a thicket. Numerous varieties (about forty) of these plants are characteristic of remote temperate regions; the two plantains—the broad-leaved and lancet-leaved plantain—and the true mugwort being identical with German forms. This appearance of European flora, or one so nearly akin to it, upon a solitary mountain upon an island south of the equator—while the surrounding lowlands, for a circumference of hundreds of miles, are covered with a flora of a totally different character—is a very singular fact. The peak of Teneriffe, the mountain heights of Bourbon and Mauritius, have no such Alpine flora; even similar cases are rare, while strictly parallel cases are scarcely to be found. Among such similar cases we may mention that upon the Alpine peaks and upon the Pyrenees there are plants which are absolutely identical with those of Lapland, but which are not found in the intervening lowlands. The same may be said of the plants found upon the summit of the White Mountain in the United States, and those of Labrador. The ordinary means of dispersion of plants are not sufficient to explain these cases. Many of these plants contain such heavy seeds that it would be impossible to be carried by the wind; and of course there is no question of the agency of birds. The difficulty of explanation was so great, that some naturalists were drawn to the supposition that these individual species were created twice at separate places on these remote and widely severed peaks. But geology steps in with a more satisfactory explanation, and teaches us that in prehistoric times snow and ice covered the mountainous districts of central Europe and a great part of America; that a climate prevailed in those places similar to that of Greenland and Labrador at the present day; and that then an arctic flora was found in both continents. When this age of ice came to an end, and the snow began to disappear, the glaciers slipping down from the heights, and retreating towards the north pole, the plants also retreated, keeping, as they do everywhere at the present day, close to the snow line; and so it happens that the same kinds are now found on the mountains of temperate Europe and America as are seen in the Arctic regions. As upon the mountains of Java, the higher slopes of the Himalayas, and on the summits of the peaks of central India and Abyssinia, we find a number of plants which, although not identical with those of the European mountain heights, may yet be considered to belong to the same species, and looked upon as their representatives; yet most of them could not live in the warm intervening districts. Darwin thinks that this class of facts may be accounted for in the same way; for during the great severity of the glacial period the vegetable forms of the temperate zone would extend to the limits of the tropics, and toward the end of that period they would retreat up the southern mountain ranges, as well as northward to the hills and plains of Europe. But in this case a long period elapsed, and the great changes of outer conditions allowed many of the plants to be so greatly modified that we look upon them now as belonging to different classes. A number of facts of similar kind have led to the supposition that the depression of temperature was at one time sufficient to allow the passage of a few plants of the north temperate zone over the high passes to the equator, and to suffer them to reach to the antarctic region, where they are found at the present day. The evidence in support of this supposition is found in the latter part of the second chapter of Darwin's book on the Origin of Species; and if we accept the views there brought forward, we shall find ourselves able to account for the presence of a European flora upon the volcanic rocks of Java. It will, however, be objected that the sea extends in a wide expanse between Java and the mainland, and must therefore have effectually prevented any introduction of foreign plants. In answer to this, there is abundant evidence to prove that Java was once united to Asia; the most striking proof of such connection being the presence in Java of the great mammals, the rhinoceros, tiger, banteng or wild ox of Siam and Burmah; for those animals have certainly not been introduced by men. But it will suffice here to refer to what has been said before.

Java is well stocked with indigenous mammals; it possesses fifty-five species, with ninety genera, among which five are peculiar: three monkeys, a small deer, and a wild pig. According to this estimate, the island is poor in comparison to Borneo and Sumatra; for of the animals mentioned as belonging to the latter places, the orang-outang, siamang, tapir, and elephant are wanting; many kinds of birds, also, which are found in Borneo, are missing here; while, on the other hand, there are in Java twelve varieties of birds which have allied species on the Himalayas, in Hindustan, and Burmah, but are unknown in all the other Sunda Islands.

The small deer mentioned above is the *Tragulus kantchil*, a pretty animal, which measures about eighteen inches long and stands eight inches high. It lives more frequently in the mountains than on the plains, and especially in the outskirts of the great forests. All the movements of this little creature, Brehm tells us, are extremely light and elegant, but, at the same time, very swift. It can take comparatively wide leaps, and is very clever in evading all the difficulties besetting its track; but its slender limbs soon refuse their support, and it would speedily fall a prey to its pursuers, if it did not possess a peculiar method of defence, which consists in a singular stratagem. It generally tries to hide from pursuit in the bush, but as soon as it sees that escape is impossible it lies quietly on the ground, and, like the opossum under similar circumstances, pretends to be dead. The enemy approaches, thinking to seize his booty, when behold, before he reaches the spot, the little creature jumps up, and is out of sight with one or two springs. Raffles says that when the Malays wish to find words in which to describe a thorough-paced deceiver, they call him "as cunning as a kantchil." Of monkeys, the *Semnopithecus maurus* deserves mention. It is five feet long, half of the length being taken up by the tail. In old age it is as black as velvet, and is distinguished by a peculiar growth of hair which projects over the forehead and on both sides of the face. It inhabits the large forests in troops, and is hunted by the natives for its skin; but is never kept in captivity like the lutung, a red monkey, which is perhaps a variety of the budeng, and is a great favourite with the Javanese.

Junghuhn, in describing the manners of a wild dog (*Cuon rutilans*), writes as follows:—

"As I came out of the bush on the coast of Tandjung-Sodong, and looked across the wide sandy shore, as far as the tongue of land, Pangarak or Turtle, I thought I saw a field of battle before me. Hundreds of skeletons of enormous turtles lay scattered about on the sand. Some of them, bleached by the sun, consisted merely of smooth bones, some were still filled by the putrefying intestines; others again were fresh and bleeding, all were lying upon their backs. This is the place where the turtles are attacked by wild dogs as they wander by night from the sea along the shores and back to the water. The dogs come up in bands of twenty to thirty animals, seize upon the tortoises by any undefended part of their body, the feet, the head, the end of the tail, and by their united power succeed in upsetting the turtle, notwithstanding its enormous size, so that it lies helpless upon its back. Then they begin to bite it everywhere, tearing out the inside, and devouring the intestines, the flesh, and the eggs. Many turtles manage to escape from these savage enemies, and reach the sea in safety. But sometimes the dogs are not allowed to finish their repast undisturbed. Many a time it happens that the king of the wilderness, the royal tiger, breaks forth from the woods, stands still for a moment, examines the sand with sparkling eyes, then steals gently up, and at last springs with a low growling roar among the pack of dogs which scatter in all directions, and betake themselves in headlong flight to the woods. A short shrill cry accompanies their retreat. In this way the perpetual battle is waged between them and the denizens of the sea in a place barren and desolate beyond all description, and never visited by Javanese, but marked out to the traveller from a great distance, by the number of birds of prey circling high overhead in the air."

Celebes.

The oddly shaped island of Celebes is mountainous on the whole, but nevertheless possesses extensive plains and lowlands. The climate in the south is rather dry, consequently the woods there are but poorly represented, and are thorny; while in the north there is a luxuriant forest growth and a moist climate. Deep seas surround the islands, but there are also coral and volcanic islands, which seem to indicate former upheavals and depressions. The distribution of their organisms is one of the most singular problems; the limits of definite plants and animal forms do not coincide; the flora is Indian; the fauna is more Australian; the former corresponds to the climatic, the latter to the local peculiarities.

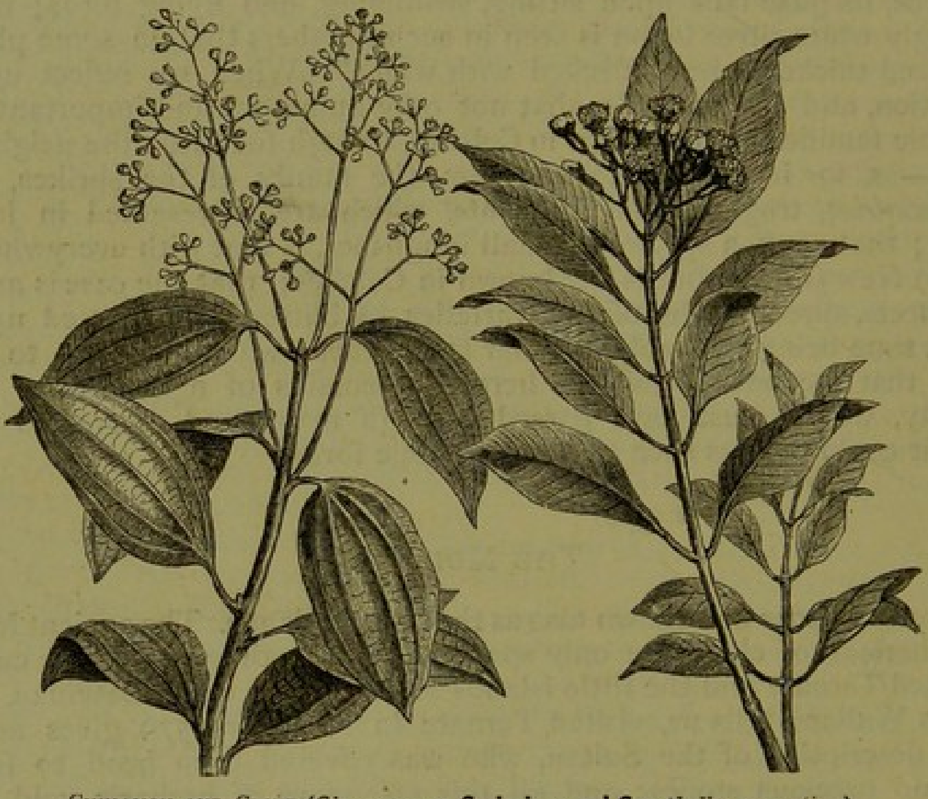
Von Rosenberg travelled through the Bay of Tomini, the most northerly of the three great bays which give to the island its very singular shape. In the south the coast is flat, with a mountainous chain in the distance, supposed to be about 3,000 feet in height. There were no traces of cultivation of the soil to be perceived. Near the village of Posso, the flat coast rises to low chains of hills, which seem to be entirely disconnected from the mountain chains which run further into the interior. The ground is covered with wood, in which, especially on the right bank of the river, many gardens and dry rice fields are met with. Round the houses, the cocoa-nut, the usual fruit trees, maize, bananas, and sugar-cane are cultivated. Although the whole land is covered with woodland as far as the eye can reach, the general character of the vegetation is scanty. The delta of the river Bongka is planted with high grasses and the *Casuarina muricata*. The eye is struck at once by the large pyramidal blossoms and leafless boughs of the latter, which recall Australia, the continent from which it probably comes. There is little worthy of notice to be said of the little Togean Islands, except that the natives feed principally upon batatas and sago.

The fauna, especially the mammals and birds, is much more interesting than the flora. Among monkeys, we find the large black baboon (*Cynopithecus nigrescens*), a local variety of the tailed baboon (*Cynopithecus niger*), which is said to be a native of the Philippines, but which is perhaps only a variety of the kind indigenous to Celebes, and until now the only variety in that island. It is frequently met with in the forests of the mountains, and assembles sometimes in troops of hundreds, to wander from one place to another. The goblin monkey (*Tarsius spectrum*), a charming little creature, lives in the woods, sleeping by day in hollow trees, and visiting the orchards by night. In its movement along the ground it proceeds by leaps, recalling the motion of a frog. There are several kinds of chiroptera, five bats being peculiar to Celebes. There is also a marten (*Paradoxurus muschenbroeki*), which lives only in the mountains, but is often dangerous to the domestic animals of outlying houses, and is very difficult to capture. Celebes has two kinds of cuscus (*phalangista*), and five peculiar varieties of squirrel. Another animal found only in this place is the forest ox (*Anoa depressicornus*), a small, straight-horned buffalo, which is not exactly rare, but is difficult to capture. The Celebes pig (*Sus celebensis*) is a peculiar kind of wild pig; and the *babirusa alfurus*, or hog-deer, is a peculiar form, which has no kindred species; while the wood rats (*gymnomys*) recall Australian varieties. As domestic animals, the natives keep dogs, cats, goats, sheep, pigs, horses, cows, and buffaloes (*Bos kerabau*). It is a pretty sight to see a number of these gigantic animals quietly grazing or lying in a pool, while the dazzling white silver herons promenade comfortably upon their backs.

Although the bird fauna of Celebes cannot rival that of New Guinea and of the Moluccas, either in richness of varieties or in the brilliant colour of their plumage, they surpass that of the three other large Sunda Islands. This is true especially of parrots, kingfishers, and doves. Nearly 205 specimens, of which eighty-six are peculiar to Celebes, have been observed; of the remainder, fifty-five are of oriental and twenty-two of Australian origin, the rest being common to the two regions. It is not our intention to mention here all worthy of notice; but we must not pass over a bird belonging to the family of brush turkeys (*Megacephalon maleo*). The number of aquatic and marsh birds surpasses belief, both on the lake of Limbotto and along its banks. "What I saw there," writes Von Rosenberg, "far exceeded my boldest expectations, both in the number of species, and of individuals; wherever the eye turns, its gaze falls upon sitting, swimming, and flying birds; while the dazzlingly white silver heron is seen in such numbers that in some places the green reed thicket appears flecked with white." When we reflect upon this description, and then consider that not only numerous and important genera, but whole families are unknown in Celebes, though found on the neighbouring islands—as, for instance, among others, the family of the shrikes, barbets (*Megalæmidæ*), trogons, and pheasants, which are represented in Java and Borneo; that ceyx, a species of small kingfisher, is met with everywhere from India to New Guinea, but is not known in Celebes; that the case is analogous with insects, three-fourths of the varieties of butterflies collected up to the present time being probably peculiar to Celebes—we are brought to the conviction that we have before us here the remains of a country of extreme antiquity, which must have passed through many and diversified changes before it could possess such peculiar organic forms.

The Moluccas

The Moluccas are known also as the Spice Islands. The ancient Moluccas, the fatherland of clove, the only spot upon the earth where it was cultivated, contained Ternate and the little islands southward as far as Batchian. Drake, who, as Wallace tells us, visited Ternate in the year 1579, gives an enthusiastic description of the Sultan, who was covered from head to foot with gold and precious stones; and all this splendour of barbaric gold was the produce of the spice trade, which was a monopoly in the Sultan's hands. Nutmegs and mace were obtained from the natives of New Guinea and the neighbouring islands, where they grew wild; and the profits on spices were so great, that the European traders gladly gave gold, precious stones, and the rarest productions of Europe in exchange. When, however, the Dutch obtained an influential position in these islands, and liberated the natives from their Portuguese oppressors, they saw that the easiest way in which to repay themselves was to get the spice trade into their own hands. For this purpose they conceived the clever idea of concentrating the cultivation of spices in those places over which they held the mastery, and where they were in a position to control it. In order to carry out this plan effectually, it was necessary to ruin the culture and trade of every other place; and this they did by making terms with the native rulers. The latter agreed that all the spice plants in their territory should be destroyed. They gave up a large but fluctuating income, and received in exchange, not only a fixed revenue, but also a freedom from the continual attacks and oppressive yoke of the Portuguese, and the right of royal power and exclusive authority over their own subjects, which is maintained up to this present time in all the islands with the exception of Ternate. It is certain, Wallace tells us, that very many people who are accustomed to look upon this act of the Dutch as something unprincipled and barbarous, suppose that the native population suffered grievously by the destruction of such a valuable property. But it is clear that such was not the case. The Sultans kept the trade in their own hands as a strict monopoly, and took care that their subjects received no more than their usual wages; while, as a matter of course, they themselves grew as much of the valuable spices as they possibly could. Now it is obvious that by the absorption of so much labour on the production of one single article, the price



CINNAMON AND CLOVE (*Cinnamomum Ceylonicum* and *Carophyllus aromaticus*).

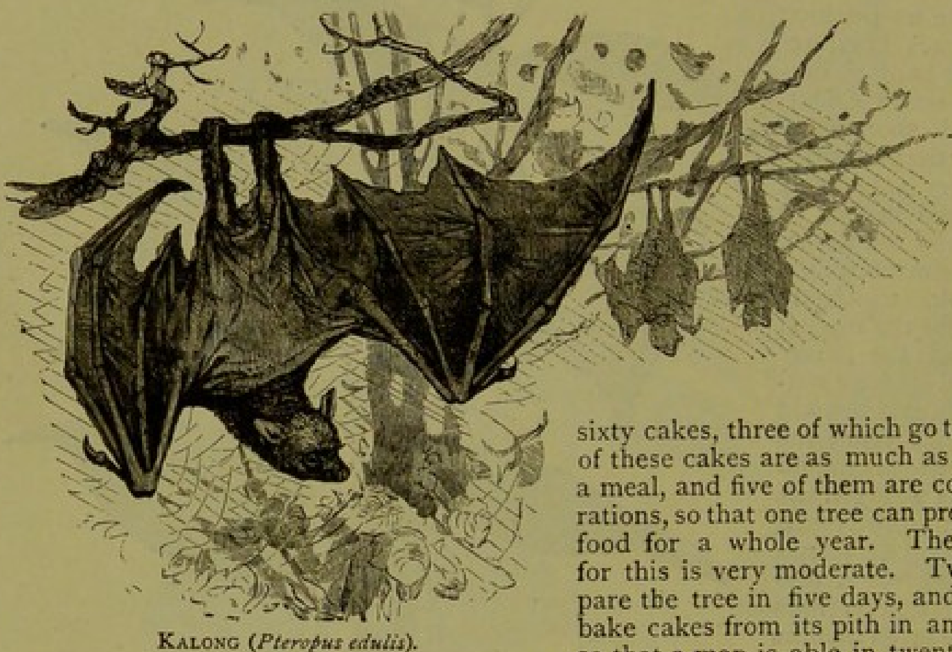
of food and other necessaries of life must have been greatly raised; and that when the spice trade was done away with, men were at liberty to grow more rice and sago, catch more fish, and obtain more tortoiseshell, rotang, dammar gum, and other valuable products of the forest and the sea; and therefore that the destruction of the spice trade was an actual benefit to the inhabitants, and that consequently the deed is justifiable both in its moral and political aspect. Banda was the place selected for the cultivation of nutmeg. It is extremely fertile, and even at the present day yields a large quantity of the spice, and brings in a good yearly profit. Amboyna was the head-quarters of the clove trade; but neither the soil nor the climate, although apparently very similar to those of its native land, was favourable to the crops; and for some years past the government, owing to the great fall of prices, has paid the planters actually more than they received from the sale of the spice, the tariff having been fixed for a certain number of years by the Dutch government itself, which honourably paid, though losing by the agreement.

The cloves of commerce are soaked in boiling water, dried, and exposed for a few days in the smoke. They are the small blossoms of the aromatic plant, *Carophyllus aromaticus*. In their fresh state the petals are milk white, and surrounded by a beautiful red calyx. The plant itself, with its thick leathery leaves, is not unlike a laurel grown in a pyramidal shape. It is now grown in many places besides the Moluccas; for instance, in Mauritius, the East Indies, the Antilles, Dutch Guiana, and Brazil. The clove tree only attains the moderate height of from forty to sixty inches; while its neighbour, the nutmeg tree (*Myristica fragrans*), towers above it to the height of forty or fifty feet. The latter tree is pyramidal in form; its branches, standing round the stem in a circle, form a crown of twenty-five feet in diameter. The insignificant-looking little blossoms are white, and grow in small grape-like clusters, and if it were not for their great abundance and their arrangement into clusters, would almost be lost amid the luxuriant foliage of the thick leaves. From these blossoms is developed the valuable fruit, which is about two inches long, resembling globular hanging berries of a deep ochre colour, and covered with short silky hairs. Gradually the pulp dries up into a leathery substance, and, bursting open in two or three places, allows the kernel to be seen. A crimson, pulpy, irregular network, which is dried and sent into the market as mace, surrounds the glossy chestnut-coloured seed, or nutmeg. The tree is said to yield first in its seventh year; the crops attaining their maximum of productiveness between the fifteenth and twenty-third years, but it sometimes bears fruit to its eightieth year. A ten-year-old tree yields 2,000 fruits yearly, which take seven months to ripen.

NUTMEG PLANT (*Myristica fragrans*).

Second in rank to these productions of the Moluccan flora rank the famous fruits of the Sunda Islands, the durian, mango, lansat, banana, and mangustane; but it would be a great mistake to suppose that all those valuable trees grow wild. They are all as much cultivated plants as our varieties of fruit; and there, as here, careful, intelligent culture is rewarded by the transformation of worthless plants into valuable and productive ones. By planting the trees in more open positions, the sun obtains more power over the fruits, and increases the sugar they contain, and their size and flavour; and as the trees perpetuate their good qualities to their successors, the result at last obtained is a fruit very little like that of the original plant. The case is just the same with our own trees, as is easily seen by a comparison of the crab apple with the fine fruits brought to our tables at dessert. Thus, upon the island of Batchiari, there are genuine wild bananas; but their full-grown fruit is hardly as large as a thumb, and consists only of a mass of seeds, covered with a thin layer of pulp and a rough skin. There is also no lack of cocoa-nuts. The fermented juice of the flower stems is made into a pleasant-tasted palm wine, which has something of the flavour of cider, and is strongly intoxicating. A delicious beverage is also obtained from the water of the young fruit; it is considered a great delicacy, while the milk of the ripe nut is thrown away as worthless, although it is infinitely superior to that of the old dry nuts which we buy.

The island of Ceram is the principal district for the growth of sago, and from its harvests most of the surrounding islands obtain their chief article of food. Wallace describes the whole process of its preparation, and gives very interesting statistical details. The sago tree (*sagos Rumphii* and *sagos farinifera*) is a palm thicker than the cocoa, but seldom growing to as great a height. Its prickly, feathery leaves are from twelve to fifteen feet long, and cover the stem entirely until the tree is many years old. The centre ribs or veins of these giant leaves are used instead of bamboo for several purposes, and in many cases are more useful even than the bamboo itself. They are considered among the most useful productions of the country. Houses are built entirely of them, and they are only excelled in value by the pith extracted from the stem. To prepare sago from the latter, a full-grown tree is selected before it begins to blossom, which, it may be said in passing, is when the tree is from ten to fifteen years old. It is cut down close to the ground, the leaves and their stalks are removed, and a broad strip of the bark is cut out of the upper side of the stem. The pithy substance so exposed is then broken with a club, and by washing in water is separated into its two component parts, of nutritious flour and woody fibre. The starch is reddish in colour, and is sent into the market in cylindrical pieces weighing about thirty pounds each. It is an extraordinary sight to see a whole tree trunk, perhaps twenty feet long and sixty inches in circumference, converted into an article of food, and that with so little work and preparation. A tree of average size yields thirty tomans, or pieces of thirty pounds, and every toman yields sixty cakes, three of which go to a pound. Two of these cakes are as much as a man can eat at a meal, and five of them are considered a day's rations, so that one tree can provide a man with food for a whole year. The labour required for this is very moderate. Two men can prepare the tree in five days, and two women can bake cakes from its pith in another five days; so that a man is able in twenty days (Wallace, by an error, says ten days) to provide food for the whole year. This supposes, of course, that the man possesses sago trees, for they are now all of them private property. If he has no tree of his own, he has to pay about seven-and-sixpence for one, and as labour is worth about sixpence a day, the price of food for one man during the year comes to about seventeen-and-sixpence. The result of this cheapness of food is an unmitigated evil, for the inhabitants of sago-growing countries are never so well off as those in which rice is cultivated. Many of the natives never taste either fruit or vegetables, but live almost entirely on sago and a little fish.



KALONG (*Pteropus edulis*).

We have still to mention the dammar pine tree (*Dammara orientalis*), a giant forest tree, which yields large quantities of gum in great clumps of from ten to twenty pounds in weight. The gum adheres to the trunk or to the ground near it, and the inhabitants of many little villages in Batchiari are occupied exclusively in collecting and pressing it down into tubes of palm leaves, and so preparing the only candles used by many of the natives.

The Moluccas are poor in mammals. One ape is found in the island of Batchiari, a baboon indigenous also to Celebes (*Cynopithecus nigrescens*.) The archipelago has also one representative of ruminants—a stag. To this short list must be added the stag-boar (*Babirusa alfurus*), a civet-cat (*viverra tangalunga*), a small shrew-mouse, and, lastly, a few marsupials, small animals resembling opossums, among which the flying opossum (*Belideus ariel*) deserves notice.

The natives of Batchiari are almost the only people of these islands who eat the great fruit-eating bat, kalong, or flying fox (*Pteropus edulis*). The ugly creature is regarded by them as a great dainty, and is much in request as an article of food. Toward the beginning of the year these animals come in great numbers to devour the fruit, remaining during the day in one or other of the small islets in the bay, where they hang by thousands from the trees, generally choosing a dead tree for their resting-place. Their position on the tree, like that of our bats, is head downwards. They are then easily caught, or knocked down with sticks, and carried home by basketfuls. They have to be carefully prepared, for the skin and hide have a strong foxy odour, but they are cooked with many spices and additions, and, as a matter of fact, have an agreeable flavour, something like jugged hare.

When compared with the small number of mammals, the great variety of birds arouses the greater astonishment. There are 265 species, among which 195 are land birds. To appreciate this number we must remember that Europe, with its diversities of climate and vegetation, and the great number of representatives contributed to it from the wide stretch of temperate Asia, and from Africa, only possesses 257 species of land birds as constant inhabitants or regular migrants.

Foremost among birds is the helmeted cassowary (*Casuarius galeatus*), a black bird, distinguished by its coloured head, partially coloured neck, and bony helmet rising from its skull. It is well known in all the zoological gardens of Europe, although its only home is probably in the forests of Ceram. It is such a shy bird, that Wallace, who was an exceptionally fortunate collector, was not able to capture a single specimen, although it is met with in all the places which he visited.

Very numerous also are the brush turkeys (*megapodius*), to which tribe belongs the mound-makers, already mentioned as inhabiting Celebes, and also found in the Moluccas. They are dark-coloured birds, about the size of a farmyard fowl, but distinguished by their large, strong feet, furnished with sharp claws. They live generally in the thorny bramble along the sea shore, where, with the help of their claws, they throw up mounds of shells, rotten wood, seaweed, mud, etc., in which they deposit their eggs. These mounds are often seven or eight feet high, and twenty to twenty-five feet in diameter. The eggs are buried from two to three feet below the surface, and are hatched by the heat developed by the decomposing substances; and it seems as if the birds, having once entrusted their eggs to the mounds, take no more interest in them, the young birds being left to make their own way through the nest, and betake themselves to the woods.

Among the remaining classes of birds we must speak of parrots, doves, kingfishers, and sunbirds, almost all of which are bright-coloured birds, many of them with the most brilliant plumage; but woodpeckers, thrushes, magpies, tits, and pheasants are not found here, although they are so abundant in other parts of Asia.

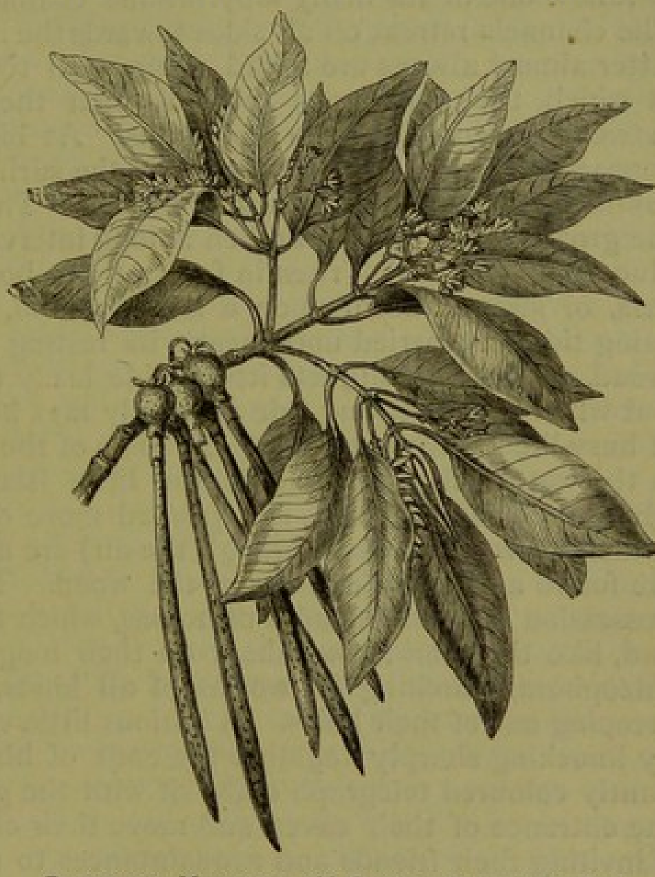
The insect world is also well represented, especially by a number of large and strikingly beautiful butterflies (*Cornithoptera* and *papilio*), as well as oddly formed beetles (*Euchirus*).

THE PHILIPPINES.

Climate and the nature of the soil together make the group of the Philippines the most capable of culture of any known islands. The chief exports are sugar, rice, coffee, and tobacco; a large profit is obtained also from cocoa, cinnamon, pepper, indigo, cocoa palm, and banana, and from the valuable timber and dyeing woods of the vast forest. The most interesting production of the vegetable world is manilla hemp, of which more than half a million hundredweight is exported. The fibre is obtained from the *Musa textilis*, a tree probably belonging to the tribe of bananas; it is made from the soft bark of the stem, and although the latter is only ten to twelve feet high, the manilla fibre comes into the market in silky threads, from seven to ten feet long, and is used for many purposes as a substitute for hemp.

The group of the Philippine Islands is surrounded by a wreath of coral banks, which are sometimes joined to the land, without, however, forming an actual reef, and sometimes appear as perfect reefs, either coast or bar reefs —the latter, however, being very rarely found—and rendering the countless arms of the sea between the islands still narrower. The Malays, who live along the coasts, reap a rich harvest at every turn from the valuable products of the tropical sea. First of all rank the holuthuria, which are sold as trepang, and the exportation of which to China, though fluctuating considerably, according to the amount caught in the fishing season, often exceeds half a million pounds. As articles of trade taken from the numerous molluscs, we must give the first place to the pearl oyster (*Meleagrina margaritifera*) and the pearl shell (*Placuna placenta*), both of which are of less value for their pearls than for the shells themselves. The pearl fishery is now principally carried on in the waters round the Sulu Islands, Palawan, and Mindanas, only by slaves captured in the yearly raids undertaken by the Mohammedan princes in the south of the Philippines. But the large pearl shells, the only kind which holds out a promise of good booty, retire more and more into greater depths, so that in the sea near Sulu the divers have now to descend to a depth of more than eighty feet. The heavy pressure of the great masses of water injures the strongest chest in time; and the divers whom a sudden death saves from a lingering and painful sickness are the happiest. The pearl trade in Manilla is entirely in the hands of the Chinese, and therefore it is not possible to gain any trustworthy information as to the profits; but it is known that only about a quarter of a thousand hundredweight of shells are exported yearly. The *placuna placenta* is found in the mud of the river mouths, and square pieces are cut out of their flat, thin and very transparent shells, and are used instead of glass panes in the window frames in China, the Philippines, and the islands of Further India. The cowrie shells (*Cypræa moneta*) are exported in large quantities, but their value is greatly reduced. This "porcelain snail" is whitish or yellowish in colour; shaped like a wide oval, with four blunt knobs on the edge of the side. It is from half an inch to an inch long; and is found in the greatest abundance near the Maldive Islands, where, according to former reports, it was collected twice a month, three days after the new and three days after the full moon, though it might probably be taken at other days of the month. It is shipped principally to Africa, but also to Bengal and Siam. Its chief dépôt for the African trade is Zanzibar. From the east coast of Africa, thousands of years past, large caravans loaded with this article of commerce, which is both money and goods, have been despatched to the interior. Whole cargoes are shipped from Zanzibar in European vessels to the west coast, and exchanged there for the produce of the various stations—gold dust, ivory, palm oil, etc. Many interesting details of this shell-money in the negro empires of Central Africa are found in Barth's famous description of his travels. In Gure, 70,000 shells were rated at £1 19s., and the revenue of the sovereign amounted to 30 million cowries. Their value fluctuates, of course, with the amount imported and the distance from which they are brought. They are generally strung by hundreds on a string, to make them easier to reckon. In some places, however, this is not done, and thousands have to be counted one by one. According to the report published by Beckmann in 1793, Ceylon, as long as it remained in the hands of the Dutch, was the head-quarters of the cowrie trade, and they were exported in baskets and bales of 12,000 shells each, or in casks destined for Guinea.

For a long time the whole African slave trade was carried on by exchange of cowries; five or six slaves being purchased for 120 pounds of shells. Towards the middle of the eighteenth century, the price had doubled; and afterwards, when the whole coast line was inundated with the shell-money, other objects of barter were used in its place.



Rhizophora Mangrove, with flowers and germinating fruit.

About 25 cwt. of tortoise-shell is obtained. The dujong (*Halicore dujong*) is a curious marine mammal of the order of *Sirenæ*, which is eagerly sought for food. Its flesh has a pleasant flavour, and its first vertebral joint is bestowed as a mark of distinction by the chiefs of the country. It is worn on the wrist, upon which it can only be placed by a difficult and very painful process. There are no carnivora; but apes, snakes, turtles, crocodiles, fowl, pigeons, and parrots have numerous representatives. Next to rice, the principal food of the natives consists of fish, most of the towns and villages being situated upon the sea shore. At low tide the population go out to the coral reef in pursuit of a sea eel, which is caught by harpooning. They stupefy, by the use of poisonous roots, all the fish which are found hiding in the water under a large block of coral, and at night they put out in boats, and row along the coast, carrying burning torches, and spearing the fish which rise dazzled by the flame. At certain seasons immense shoals of fish ascend the mouths of the rivers, and are caught by millions, salted, and used as an important article of commerce for the interior. One curious species—the dalag, of the ophiocephalus family—is a fish which is often found upon the dry land, and which it is believed can breathe the air. In the hot season, when the brooks and marshes become dry, they retreat into the mud, and sink into a kind of winter sleep, until they are aroused by the heavy rains which fall in the month of May. They then come forth in shoals, and are captured by hundreds of thousands.

Semper, who spent nearly two years in the Palau Islands, near to the

Philippines, in the Pacific Ocean, describes the mangrove swamps of the island of Babelthaub, which is the largest of the group. "We sailed along the coast," he says, "at high water, keeping rather near the land, which is everywhere fringed by groves of mangrove trees. Numberless straight slender stems rise from the splashing water to the height of six feet, and then suddenly break out into a crown of irregular branches, with broad, succulent, glossy green leaves. The roots stand partially above the sea, as thin, tangled forms, which, seen from a distance, look like a mound of irregularly piled ruins. Between the roots, dead stems, or stiff, pointed young trees are seen, and hanging down from the branches, breaking forth from the dead blossoms, the freshly germinating roots thrust themselves vertically downward to the water below. The thicket at first appears to be of small extent; but on attempting to follow one of its many labyrinthine channels, one is amazed at its extent. The channels retreat on all sides towards the interior between the hills, and the latter almost always are found rising with their steep base from the swamps in which the mangroves grow, so that there is actually no level ground between the coast and the mountains. At high tide most of the rhizophora appear like single stems rising above the surface of the sea, and the tangled confusion of the roots is entirely hidden. Then a profound silence reigns in the groves, which is only broken at long intervals by the hoarse cry of a brilliant blue kingfisher, which rises in front of the boat, startled by the plash of the oars, or swoops down upon a shoal of fish, which the swift current of the rising tide has carried underneath its resting place. A water snake, with a broad, rudder-like tail, lets itself glide lazily down the centre of the stream. But when the retreating tide gradually lays bare the marshy soil, many a sign of busy life breaks out among the roots of the trees, in the branches overhead, in the watery channels, and in the little islands formed by the mud, which, where the channels cross, is deposited more quickly than the mangrove roots (which grow *downward* through the air) are able to absorb. Here and there are found artificial clearings in the wood. These half-dry places are taken possession of by multitudes of herons, which flock to them from all quarters, and, like the stork, strut about on their long legs, between the roots of the rhizophora, searching for worms of all kinds, which are found by thousands creeping out of their holes. A curious little crab utters loud cracking sounds, by knocking sharply together the ends of his scissors-like claws. The brilliantly coloured telegraph crabs sit with the gigantic one-sided pincers before the entrance of their caves, and move their claw perpetually up and down, as if inviting their friends and acquaintances to enter. Elegant snipe and wagtails run swiftly to and fro, and a mass of lung-breathing snails leave the holes and rifts in which the water had shut them up with only a small quantity of air, to enjoy the bright sunshine, and take in a fresh provision of pure air. Large marauding land crabs move now about the labyrinth, hunting for the snails of the salt-water marshes, or breaking with their powerful claws the large shells hidden in the mud. Man also joins them in their pursuit after the edible shells; but the returning tide swiftly brings all the busy scene to a close again for a short time.

If we were to follow up the distribution of the vegetable world, this would be the proper place to speak of New Guinea and the countless islands of the Pacific Ocean which belong to the monsoon district, but are included in the Australian region.

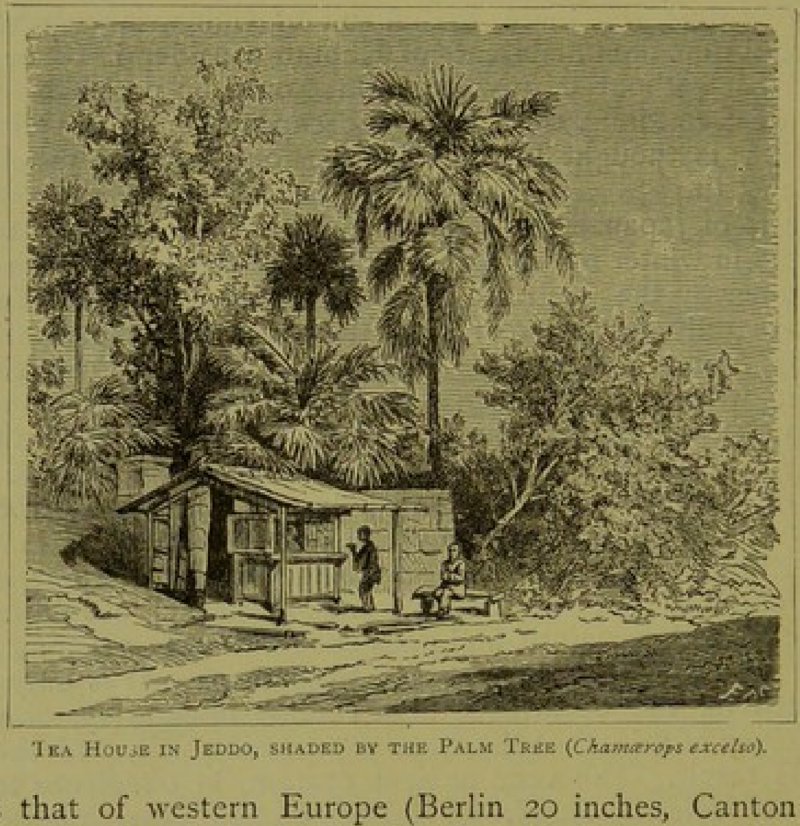
EASTERN ASIA.

The part of Asia still remaining to be considered, and which we call by the name of Eastern Asia, corresponds essentially with the Chino-Japanese vegetable district and the Mantchurian sub-region. The three great climatic factors which determine the flora of this region are the summer temperature and the amount and the regularity of the rainfall. Pekin, which is situated in about the same latitude as Corfu, has a summer like that of Cairo, but a winter like that of Upsala. The heat in July reaches 108°, and falls in the night to 95° Fahr. The air is so dry that no hygrometer can act, and it vibrates over the heated ground like the vapour over an oven plate. In November the rivers and seas are covered with ice a foot thick, and do not thaw before March. Burning desert winds from Central Asia sweep over the coast lands in May and June, and envelope ships, even miles out at sea, in clouds of thick yellow dust. This fine dust, the loose, friable soil of China, is extremely fertile; indeed, it is said that the inhabitants of Khotan consider it to be as good as manure, and that without it no vegetation would be possible. While these tempests of dust continue, the whole landscape assumes a yellow tint, and therefore yellow is thought by the Chinese to be the holy colour, and to symbolize the earth.

The coasts of Japan enjoy a much greater uniformity of temperature; they are heated in winter by the warm equatorial currents of the Pacific, and cooled in summer by the fresh sea breezes; consequently snow falls in Jeddo on a few days only in the year, and the summer temperature is seldom more than 93° Fahr., but yet the majestic heights of Fusi Yama (14,000 feet) are often without snow for months together.

While in cisalpine Europe the husbandman has often reason to complain of too much rain, or too long drought, fruitful and unproductive years occur in turn, and the inhabitants are on the whole well contented if they obtain an average harvest; in China, and to a certain extent the same may be said of Japan, the culture of the soil is so arranged that the maximum yield is almost certain to be obtained; the weather, with its alternations of rain and sunshine, can be predicted with certainty, and does not hinder the ripening of the seed, if the proper kind is chosen for the respective season. It is only in very rare instances, such as the occurrence of a sudden inundation, or what is still rarer, the absence of rain, that the crops can possibly fail, and then famine is the inevitable result. The very ancient custom, in obedience to which the sovereign of the Celestial Empire guides the plough yearly along the furrow, shews how early it was recognised that the welfare of the people is dependent upon the careful tillage of the soil; but it is erroneous to suppose that the fertility of the Chinese agricultural lands is due to anything resembling the garden-like order and scientific adaptation of the manure to the different kind of soil which is understood among ourselves. Diligent and careful labour only support and increase the advantages already obtained by a favourable climate and a rich soil, and there is little doubt that, with scientific European culture, the yield would be doubled. The great part played by the fine rich soil, composed of a mixture of yellowish clay, sand, and carbonised lime, has been noticed by many writers. While in the southern provinces of China, where the climate and the rainfall are very favourable, and two or even three harvests can be obtained with ease—where the soil is often very moist and even the hills are covered with a luxuriant vegetation—agriculture is seldom carried on at greater heights than 1,970 feet; in the north, the region of the yellow earth, the ground is sown to a far greater height above the level of the sea. In the northern part of Shanse, agriculture is possible at the height of 6,560 feet, and good crops are obtained in some places at 7,870 feet, although the climate is cold, and the distribution of the rainfall less favourable.

But while the fruitful crust of the earth is everywhere serviceable to men, animals are left far less well provided with sustenance. No meadow land, no fodder is seen, nothing but barren rocks near the cultivated fields and terraces. In order, therefore, to supply the manure obtainable wherever cattle-breeding is attended to, not only is every kind of filth and putrid matter collected from the towns, and stored to the great disgust and annoyance of the traveller, but also many green plants are cultivated for this purpose. As to the original vegetation, it has in China been forced to retreat to the heights for want of space, and yet how rich it is! The annual rainfall, which is more than twice



Tea House in Jeddo, shaded by the Palm Tree (*Chamærops excelso*).

as great as that of western Europe (Berlin 20 inches, Canton 79 inches), supplies numerous tropical plants with the requisite amount of moisture. Bamboos, for instance, flourish well, and that is why the Chinese and Japanese flora presents the appearance of a mixture of European, Siberian and Indian forms.

Very striking is the number of trees, which, according to Miguel, make up about a fourth of the known species of plants. Pines and laurels are found in the first rank. Already near Canton the scanty forest growth which still lingers on the rocky hills of the coast is composed exclusively of a pine (*pinus Chinensis*) very similar to the European fir, and from Japan alone we have already thirty known species of conifers. Some of them are distinguished by their size and the beautiful regularity of their growth; such as the umbrella pine of Japan (*Sciadopitys*), and a fir (*pinus Bungeana*), which sends up from eight to ten shoots at a little distance from the ground, and twines the upper end of the stiff mast-like stem into a tangled crown of branching foliage. Other species are distinguished by their leafage; thus the podocarpus has a kind of olive leaf, and the leaf of the gingko is especially singular, rhomboid in form, serrated in front, and almost without a parallel among the leaves of trees. The Chinese cypress (*Cupressus funebris*) seems to be peculiarly adapted for the decoration of burial grounds, its dark sombre branches, with their dusky green leaves, combine, with their drooping willow-like form and gloomy colouring, the varied symbolisms of sorrow.

The principal trees belonging to the laurel tribe are evergreen oaks, laurels, magnolias, ternströmiaceæ, and camellias. All these plants become more and more rare as we advance northward, and make way for other tree forms, such as beeches, chestnuts, elms, lindens, ash, sycamore, and maple, which are met with in peculiar varieties and great numbers. Palms are rare; but the dwarf palm (*Chamærops excelso*) gives to the scenery of Jeddo something of a tropical character. Bamboos, on the other hand, are very abundant, fourteen species being known in Japan alone. The flowers and flowering trees of Japan are numerous, and celebrated throughout the world as ornamental plants of the first rank.

The awaking of nature in springtime is glorious. As early as the month of January, in the gardens of Jeddo, apricots, camellias, medlars, and cornel blossom; in February, violets, anemones, dandelion, and cinerarias; in March, spurge, aloes or mezereon, kerrias, primulas, honeysuckle, and calycanthus, with many kinds of plums, cherries, and peaches. April brings back the evergreen foliage, laurels, myrtles, and oaks, into full leaf. The woods break out into rich colouring, glorious azaleas, magnolias, pœonies, guelder roses, hawthorn and bramble bushes, paulownia (*paulownia imperialis*), the trumpet tree (*catalpa*), the glycinia, quince, and many other kinds develop their delicious splendour of blossoms. In May and June come the wild roses, deutzias, storax, pinks, asters, clematis, and sword lilies. July brings in oranges and orchids. The bamboo sends forth succulent juicy shoots, and the banana unfolds its broad network of leaves. Lilies, cock's comb (*celosia*), fox-tail, labiatæ, and other flowers, convolvulus, and mallows are gay in field and garden: on the surface of the lakes the sacred lotus spreads abroad its luxuriant tangle of twisted tendrils, and opens its fragrant blossoms. In August the brightness of the floral display is somewhat dimmed, except as regards a few forms, such as bignonias. In September, umbelliferous flowers, gentians, bluebells, everlastings (*xeranthemum*) appear. In October, roses, jasmine, deutzias, kerrias, and others blossom for the second time. Asters, anemones, and autumnal starwort adorn the gardens. The latter flower is the favourite of the Japanese; it grows to an immense height, and is rightly part of the arms of the Mikado family. The conifers now renew their leaves. In November only a few kinds of roses, camellias, tea flowers, and tazettas appear. December has scarcely any flowers; but the winter sleep of the plants is short, and there is scarcely any day on which a varied nosegay may not be gathered from the gardens of Japan.

The story that in Japan the flowers have no scent and the birds do not sing is utterly erroneous. It is true that the Japanese have fewer singing birds than we have, and that they, like ourselves, have flowers and plants which have no fragrance, but all those which are fragrant by nature smell as sweet in Japan as they do elsewhere. As the Japanese have always been diligent in introducing the useful and ornamental plants of other nations into their own fatherland, many of these imported plants have become and are found growing wild, so that it is difficult at the present time to gain an accurate idea of the indigenous plants. It is said by Von Siebold, that of the five hundred useful and ornamental plants cultivated in Japan, more than half are importations from abroad: among others, rapeseed, weld (*reseda luteola*), tobacco, safflower, poppy, hemp, sesamum, cotton, orange, pomegranate, peaches, apricots, pears, and quinces. Besides these the best fruits are grapes, water melons, gourds, plums, citrons, almonds, cherries, medlars cactus figs, walnuts, raspberries, chestnuts, salisburia nuts, the *diospyros kaki* or quince fig, an agreeable and refreshing fruit, and the *litchi euphorbia punicea* or *nephelia litchi*, a fruit resembling a delicate sweet plum, but having a piquant flavour of turpentine. Strawberries are grown in the gardens, and there is a rather tasteless kind found wild in the woods.

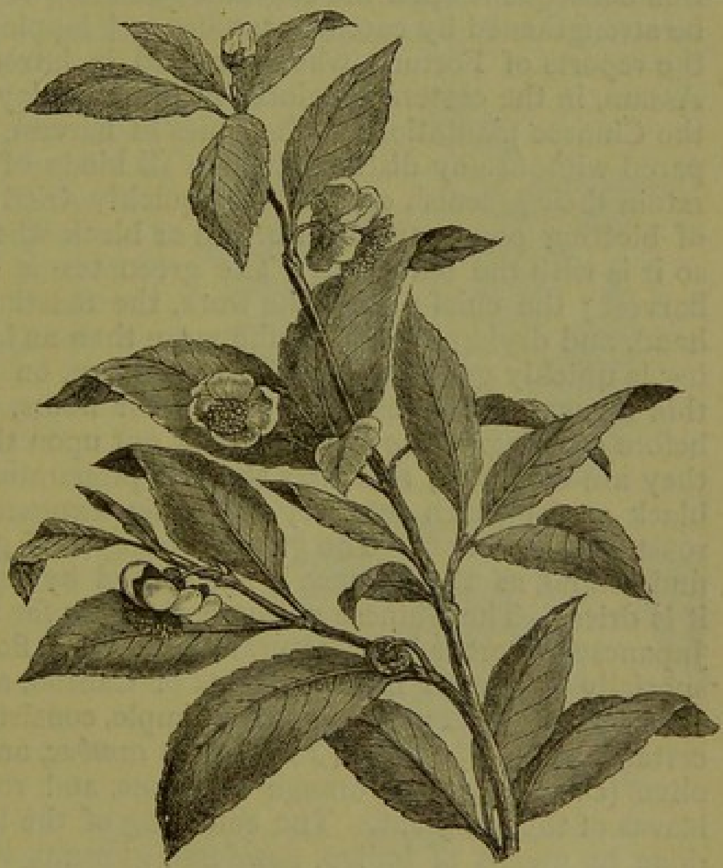
Rice is the chief object of field culture; but in the lowlands we find also tarro (kalo, *Colocasia esculenta*), an arum growth with tuberous roots, which are sharp and poisonous uncooked, but when boiled or roasted are both agreeable and nutritious. A plant with eatable tubers (*Scirpus tuberosus*), and the rush of the Japanese mats, *Juncus effusus*. The sacred lotus (*nelumbium*), the roots of which are partly eaten as vegetables, and partly made into a kind of arrowroot, grows freely in summer-time upon the lakes and rivers.

On the precipitous and high-lying fields, which are not adapted for rice culture, corn, barley, rapeseed, cabbage, buckwheat, beans, peas, and onions are grown for winter stuff. The summer produce, on the other hand, is cotton, sesamum, the egg plant (*Solanum melonenga*), maize, hill-rice (a kind of rice which requires less moisture), millet, radish, various kinds of turnips, onions, poppy, garlic, cucumbers, melons, batata, ginger, yam, tarro, lentils, peas, and several kinds of beans, especially the soya bean.

The Japanese are famous for their fanciful taste in gardening, and their hobbies with respect to the culture of greenhouse plants. According to the report of the Prussian expedition to Eastern Asia in 1860-61, almost every house in the narrow streets of the trading quarter has its own little patch of green. Perhaps this necessity of limiting the space allotted to each house has helped to develop the fancy for the cultivation of dwarf plants. In the year 1826, Meylan saw a box about one and a half square inch surface and three inches high, in which a bamboo, a fir, and a plum tree in full blossom were growing side by side. The price of this curiosity in gardening was £100. To obtain these miniature plants, the smallest seeds of the smallest specimens are selected, the stem is bent down and tied in a zigzag, every large shoot is removed, and the development of the lateral shoots is assisted, they in their turn being artificially bent and tied down. After some time the tree is said to adapt itself to the restraint, and, remaining within the limits prescribed to it, expends its vital power upon the production of large blossoms and immense quantities of seed. Thuja, juniper, and other coniferæ, bamboo, cherry, and plum trees, are the favourite kinds reserved for this dwarf culture. Many dwarf plants have striped or flecked leaves, and the production of such figured varieties, both dwarfed and in their natural size, is another hobby of Japanese gardening. The great number and the long continuance of such varieties, now favourites in Europe as well as in Japan—for instance, the aucuba Japonica—indicate the high antiquity of this culture.

The camellia (*Camellia Japonica*) is a native of Japan. It forms bushes, hedges, and even trees of sixty-five feet high; but the tree is too common to attract the attention of gardeners, and the regular, finely developed blossoms of European conservatories are seldom seen.

Closely akin to the camellia is the tea plant (*Thea chinensis*), with its varieties, *thea bohea* and *thea stricta*. The leaves and flowers are very similar, but rather smaller, white and five-petalled, with yellow stamens. It is often found wild in Japan, principally growing in hedgerows and the furrows of ploughed fields, near houses, and it is from such plants that the Japanese countryman supplies his household needs. The largest plantations are found in the interior of the country; the best upon the mountain slopes, where low clouds hang at the height of 450 to 800 feet above the level of the sea. The plantations are genefally found on hillsides, not too steeply inclined, and facing the east, away rrom houses, so that they may escape smoke and other vapours. The soil must be clayey, and contain iron, gravel, and black mould. The Japanese tea is considered inferior to the Chinese; but the Chinese varieties differ greatly in quality. *Thea bohea,* the tea plant of South China, is relatively of little value, either because the plant is really different from the *thea viridis* of the true tea districts, or because the tropical climate is injurious to it. The culture of the tea plant in China is comparatively recent; for although it has been used since the third century medicinally, it did not come into general use as a beverage until the end of the sixth century. Statesmen and poets welcomed its introduction, the former profiting by the beneficent gift of nature to fill the coffers of the State by heavy duties, and the latter helping them in their work, perhaps without intending it, by singing the praises of the new plant. "Tea," says an old Chinese writer, "calms the mind, softens the temper, prevents weariness, recovers from exhaustion, awakes the mental powers, and keeps off laziness; it renders the body lighter and fresher, and brightens the powers of perception." The tea plant seems to thrive best between 27° and 33° latitude N., where the average yearly temperature lies between 62° and 68° Fahr., and where heavy rain is followed by fine weather, with a great rise of temperature. The former is as necessary to a quick, luxuriant growth of the leaves, as the latter is for their fragrance and fine flavour. To gain an idea of the immense quantity of tea grown yearly in China, it is enough to say that in the year 1872, after deducting the large amount used in China itself, 214,500,000 pounds were sent out into the markets. It is not our intention to describe in detail the method of culture and preparation of the leaf from its first appearance on the glossy green slopes of the hillsides to its arrival in Europe; the

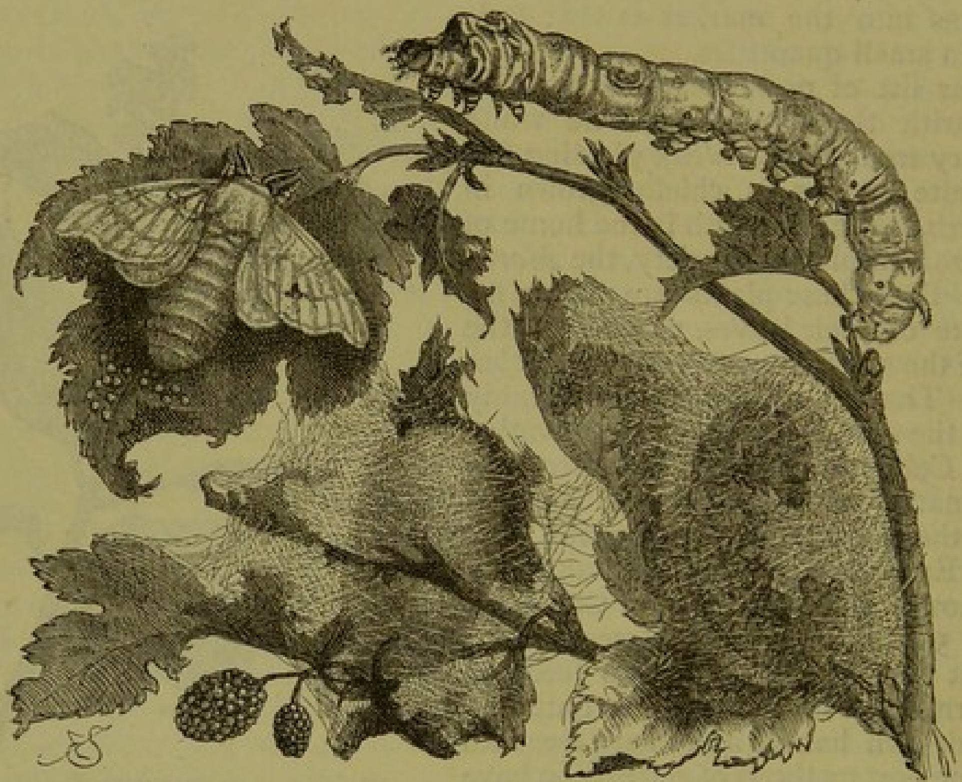


TEA PLANT.

drying and roasting, the colouring and perfuming of the leaves; in short, the whole complicated process to which it is subjected, especially as the method differs very much in different localities. In China, for instance, only the leaves and leaf-buds are gathered; while in Japan young shoots of $2\frac{1}{2}$ to $3\frac{1}{2}$ inches long are broken off and picked at home by the women and children. The plants yield first when they are four or five years old, and then they give three harvests a year. The first harvest produces the finest, and the third the worst kind. Many different qualities, however, are sorted from each harvest, for the fineness of the tea depends upon the youth and tenderness of the leaf. Ritter says that the Indian and Chinese tasters can distinguish 700 kinds of tea; other writers say only 100; and about 150 kinds come into the European market. Healthy plants yield rich crops for several years; but the exhaustion consequent upon the constant gathering tells at last, and the plant has to be strengthened by careful pruning and lopping, or replaced. According to the reports of Fortune, who succeeded in introducing the culture of tea into Assam, in the eastern provinces of the Himalayas, and who repeatedly visited the Chinese plantations at the times of harvest, black and green tea are prepared without any distinction from all kinds of plants. Just as many leaves retain their greenish colour when quickly dried in hot sand or between sheets of blotting paper, and turn brown or black when left to dry in the open air; so it is with the tea plant. The green tea is roasted immediately after the harvest; the chief part of the work, the roasting, rolling in the palm of the hand, and drying, does not take more than an hour, and the last and final drying is quickly got through. The black tea, on the contrary, is spread out in thin layers, and exposed to the air for hours, sometimes for a whole night, before roasting. The leaves are not put upon the iron pans and roasted until they are withered; and after the first preparation, which is just the same for black as for green tea, they are again exposed to the air, and then slowly roasted to finish off. The greater strength of green tea is therefore easy to understand, as the essence is not wasted by being exposed to the air before it is dried. The Chinese perfume the teas for the foreign market, while the Japanese export it in its natural state. The flowers used for this purpose are specially cultivated in many parts of Canton, and form a branch of trade in themselves. The process is very simple, consisting only of laying blossoms of certain kinds of jasmine (*Jasminium sambac*, and *J. paniculatum*), the scented olive (*Olea fragrans*), orange blossoms, and roses by the side of the dried leaves of the tea plant. The colouring of the leaves, according to Fortune, is done by means of indigo, powdered gypsum, and a plant called ma-ki-holy. Seeman says that turmeric is also used. Among the other productions of the Chinese Empire which deserve our special attention are the so-called Chinese sugar-cane (*Sorghum*, or *Holcus saccharatum*), because it is perhaps likely to put an end, or at least a limit, to the cultivation of beetroot in Europe; but the plant is said to exhaust the soil. The rice paper plant (*Fatsia*, or *Aralia papyrifera*) forms in one single period of vegetation (less than ten months) a woody stem about six feet high, which bears on its crest a rosette of long-stalked, fan-shaped leaves. The famous rice paper manufactured in the island of Formosa is made from its strongly developed pith, while Chinese paper is made from the thin bark of the two or three-year-old shoots of the paper mulberry (*Broussonetia papyrifera*). The varnish tree (*Vernix vernicia*, or *Rhus v.*), a poisonous kind of sumach, yields by its milky sap the varnish, which comes into the market in a semi-fluid state, or dried and formed into whitish cakes. It is then mixed with other ingredients, and forms the smooth and brilliant *lac* which is so much admired in articles of Chinese or Japanese manufacture. The camphor tree (*Camphora officinarum,* or *Laurus camphora*), a tree resembling a linden, with leaves like those of a laurel, is of scarcely less importance. The camphor of our shops, from Japan and China, is found scattered in the younger cellules of the plants as a liquid oil, and in the older ones as a solid substance; while the more valuable kinds obtained from Sumatra, Borneo, or Baros is deposited in the inner splits and hollows of the camphor tree of Sumatra (*Dryobalanops camphora*). Vegetable tallow is obtained from the joint of the tallow tree (*Stillingia sebifera*), and vegetable wax, or tree wax, is a waxy substance deposited on a certain species of ash by a cricket (*Flata limbata*) apparently for the protection of its eggs. It is found clinging to the twigs and branches of the tree, and the wax, procured from it by soaking it in hot water, is highly esteemed for its hardness and good quality. It is specially adapted for the manufacture of candles, and the only reason that so little of it comes into the market is that it is found in small quantities.

CAMPHOR TREE (*Camphora officinarum*).

Our list of useful plants must conclude with the mulberry. The white mulberry tree (*Morus alba*), yielding few and white berries, is chiefly grown in the north, while the south is the home of the more fruitful black variety, the *Morus nigra*. Both these plants are grown for the sake of their leaves, which form the food of the silkworm caterpillar (*Bombyx mori*). The silk rearing is indisputably one of the oldest branches of cultivation of the Celestial Empire; for, according to the native accounts, it was introduced about the year 2640 B.C., by the wife of the Emperor Hwang-te; at any rate, it is known that in the days of Confucius (about 500 B.C.) even empresses did not think it below their dignity to feed the silkworms with mulberry leaves gathered by their own hands, and many treatises upon the best methods of cultivation have been the work of imperial pens. The principal place for silkworm-rearing is the district round Shanghai, an area of about 135 to 180 miles in circumference. This land is not in the hands of a few rich landed proprietors, but of millions of small land-holders owning one or two acres of land, who, like bees, contribute their part to increase the supply; and young and old, great and small, join in the work, and are busily employed in attending to the silkworms and winding off the cocoons. According to the official reports, about 134,000 cwt. of silk were sent into the markets in the year 1879; 65,950 cwt. of the amount having been exported from China, and 10,000 cwt. from Japan; whereas Italy exported 26,600 cwt., and France 7,500 cwt., while 11,620 cwt. were sent out from Bengal, and 3,420 cwt. from Syria; and yet China is said to export only one-fourth of its annual production. The experienced merchants resident in Shanghai are of opinion that it only needs pressure from without to induce the Chinese to increase their trade tenfold, and to supply the whole world with silk; but in that case the process of manufacture would have to be greatly improved before the silk could compete with other kinds. The silk from China is admirably adapted for the manufacture of rich brocades and stuffs where the quantity of silk is of more importance than the evenness of the thread. Its special qualities are the strength of its fibre, which makes it soft and rich to the touch, and its glossy and brilliant surface. On the other hand, the inequality and want of smoothness of the single threads makes it absolutely impossible to be used in certain fabrics, such as plain velvets. Besides the mulberry silkworm, there are other butterflies which spin silk ; one of the best kinds known in Japan, and dearer there than any other sort, is obtained from the Japanese oak-tree silk-spinner (*Saturnia Yama-maya*) ; next to this come the Chinese oak-tree silk-spinner (*Saturnia Permyi*) and the *Ailanthus* spinner (*Saturnia Cynthia*). Attempts have already been made to acclimatise these three silk-spinners in Europe ;



SILKWORM (natural size), with eggs, caterpillar, cocoon, in process of spinning its covering, and butterfly on a mulberry leaf.

and although the results in the places where the trial has been made have not proved altogether successful, "because the stuff is stubborn," yet they are not to be discarded even on this ground, since the caterpillar of the first species eats oak leaves, and that of the latter the leaves of a tree which grows well in many parts of Germany (*Alanthus glandulosa*), and is therefore much easier to feed than the ordinary mulberry-eating silkworm.

Besides the silkworms and the above-named butterflies which assist most largely the productions of our modern trade, we must not forget the butterfly *Saturnia Atlas*. With one exception, it is the largest known butterfly, is of a brownish red colour, with large triangular vitreous markings. In shape it resembles its kindred form, the night peacock-eyed moth, but it is distinguished by the crescent shape of its front wings. With extended wings it measures from eight to nine inches in diameter, although its body is only one inch and a half in size.

The finest representatives of the Chino-Japanese fauna are found among the bird world. It seems as if the brilliantly coloured birds of eastern Asia reflected all the glory of colour which we admire in the oriental fabrics of silk and gold. The first rank is occupied by the pheasants, which are so characteristic of the district that it is sometimes known as the pheasant kingdom. Silver and gold pheasants (*Euplocomus nycthemerus* and *Thaumalea picta*), most of the eared pheasants (*Crossoptilon*), and horned fowl (*Ceriornis*), and the magnificent pheasant (*Lophophorus*), are natives of this region. The most numerous and characteristic representatives of the smaller birds are finches and tits belonging to the European types of those birds, but there are also a considerable number of forms of the oriental region which penetrate far into the interior of the land, and by intermingling with the northern birds impart to the country the aspect of a transition region. The great variety and richness of bird-life, when compared with the poverty of Siberia, is illustrated by the fact that east Siberia, including the comparatively rich valley of the Amoor, contains only 190 sorts, while north China and the adjoining districts of Thibet and Mangolia, a much smaller tract of land, contain 366 varieties of the same families. Moreover, Corea and Japan are very inadequately explored, so that they could not be included in this estimate; besides which, more than half the birds of Siberia belong to European species, while not quite an eighth part of the Mantchurian birds are represented in Europe.

The mammals, though less striking, are very characteristic. Small insectivora are particularly well represented. The most important mammal is perhaps the ailuropus, a denizen of the high woods. It is a kindred type to the panda, but as large as a bear, with white body, black feet and ears, and black tip to the tail. The racoon (*Nyctereutes procyonoïdes*), a remarkable member of the canine family, recalling also the marten and the bear, is found from Canton as far as the Amoor and Japan. Little hornless deer are peculiar to north China and eastern Thibet; and the musk deer belongs only to this and the Siberian subdivision. Japan possesses peculiar animal forms in the sea otter of California (*Euhydris*), and in moles and rellmice. For the rest, all the mammals of the adjoining northern districts of Asia are found here. Generally speaking, game is not exactly rare, and hunters by profession are found in Japan. They live upon the produce of the chase, and undertake to destroy all noxious beasts. In the neighbourhood of Yeddo the chase is an exclusive right of the Taikoon; stags and wild pigs are hunted, and wild geese are shot. The latter are found in great numbers near the Fusi-Yama, but only the lower class eat the flesh of animals killed in the chase.

Reptiles are scarce; or rather, probably they are insufficiently known. In the neighbourhood of Pekin are found four or five sorts of snakes, a lizard and a gekko.

We may remark, in passing, that those parts of the Indian and Pacific oceans which are situated between China and north Australia are the true home of sea snakes; not of those legendary monsters which haunt from time to time the heated imagination of sailors and the leading articles of our newspapers, but real poisonous snakes measuring from twelve to fifteen feet long. "Our ship's chaplain," says the reporter of Navara expedition, "felt, as he sat reading one night in his cabin, a peculiar pressure on his foot. The servant, whom he called up, placed a candle on the ground, and became aware, to his horror, that a large sea snake (*Chorsydrus fasciatus*) had twined itself round the chaplain's ankle. As if by instinct, the chaplain, with a sudden quick movement of his foot hurled the poisonous reptile far from him, while several persons rushed in between, and endeavoured to secure the dangerous intruder, living or dead. A campaign carried on in the narrow limits of a ship's cabin is soon over. The snake was discovered in its hiding place, and in the first onset was cut into more pieces than the zoologists of the expedition approved. The creature was only a few inches thick, and rather more than a yard long; it had come probably along the ship's anchor into the cabin." But it is not always that an encounter with one of the fifty varieties of sea serpents ends so well, and many instances are recorded in which their bite has been deadly to bathers.

GOLD PHEASANT (*Thaumalea picta*).
Cock and hen, the former 33 inches long.

The amphibia of this region are more interesting and better represented than the reptiles. The island of Nipon possesses a giant salamander about five feet long (*Cryptobranchus japonicus*), the greatest of all living amphibia.

Of fresh-water fish, the gold fish (*Carassius* or *Cyprinus auratus*) is a favourite in all aquariums, and the large-finned *Macropodus viridi-auratus* is well known in the markets.

Most of the European species of butterflies are represented; while tropical forms are comparatively rare, so that a collection of Chinese butterflies offers nothing of any special interest. The same is true of insects of the bee tribe, of which Lewis found only one exotic form; while the beetles shew a mixture of northern and tropical form similar to that which was observed in the bird world.

The Chinese take a peculiar pleasure in fishing with a cormorant (the water or sea raven, *Graculus carbo*). "We had no sooner brought to," says Heine, "than the Chinaman stretched out his hand toward one of the birds, whereupon the latter waddled up to him, and perched upon the fisherman's hand. The man stroked him, placed his lips for a moment on the head of the bird, and then placed him on the edge of the bamboo raft. The cormorant dipped his bill once or twice into the water, shook his head, waggled his tail, and suddenly dived down into the turbid flood. After about ten or fifteen seconds he reappeared with a tolerably large fish in his bill, swam up to his master, and with a joyous flutter gave him the captured booty, which the man took and dropped into a basket. The cormorant dived a second time, and in a few minutes rose again to the surface with another fish, and after being rewarded with a caress returned to the pursuit in the sea. But this time fortune seemed to fail him; for when, after the usual interval, he came in sight again, he had no fish, and seemed uncertain what to do. He turned round once or twice, keeping his eye fixed upon his master, and apparently asking permission to make another attempt. Suddenly the Chinaman made a movement with his hand, the bird shot down into the water, and reappeared with a large fish, nearly eight inches long, which was flapping violently in its struggles to get free. When the fish was placed in the basket, and the victorious bird had received his well-earned caresses with an evident air of self-satisfaction, he was set down in the centre, instead of at the side of the raft. This seemed to be the signal that his services were no longer wanted, and that he was dismissed with honourable commendation; for he strutted off to the other end of the raft with the air of a successful general, while the next cormorant came up to take his place on the side of the raft. The second bird was unlucky, and after repeated trials he was taken on board, received a few blows on the head, and was thrown aside. In great confusion he ran to the other end of the boat, stumbling many times, and looking very much ashamed and crestfallen." But Doolittle gives a somewhat different account of this method of fishing. In his opinion, as soon as the bird has caught a fish, he rises to the surface merely in the hope of devouring his prey; but as he is prevented doing so by a loose thread or ring of metal placed round his neck, he returns to the raft, and the fisherman hurries up, lest the fish should escape for the second time; for it happens sometimes, especially with the larger kinds of fish, that a lively struggle takes place between the robber and its victim."

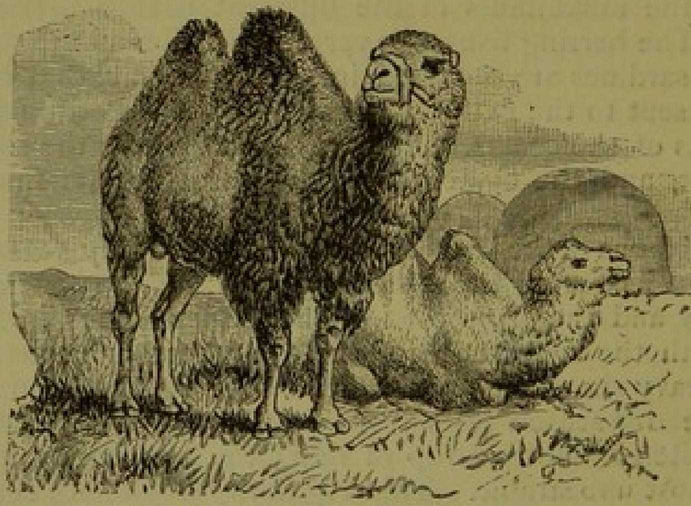
The preceding remarks have treated almost exclusively of China and Japan. The flora and fauna of Mantchuria have more resemblance to European forms. The fact that it is situated in the same parallel as France and Italy, and also in that part of the Asiatic mainland which is visited by a plentiful rainfall, leads to the conclusion, according to Wenjukow, that the soil is covered with a rich and luxuriant vegetation; and such is found to be the case. Nevertheless, the climatic circumstances are altogether different; first, it is by no means doubtful that Mantchuria is fully fourteen degrees colder than the places of the west of Europe which are situated in the same degree of latitude. In the north, beyond 56° latitude, the winter lasts for six whole months; and even in the south, in the same parallel as Naples, the snow remains lying for one and a half to two months, while the summer, as if in compensation, is extremely hot. In accordance with these climatic peculiarities, the topography of the land, and the scanty population, the vegetal covering consists principally of wood on the mountains and of pasture land on the plains. There are no steppes, but the forests, especially in the north-west (in Dauria), and in the south-east, are very abundant. The forests of Dauria consist principally of conifers, pines, larches, firs, and cedars; but on the eastern side of the great Chingan, oak, black birch, linden, cherry, maple, etc., are seen among the coniferous trees. In the little Chingan the non-coniferous trees gradually obtain the upper hand; while the elm and many shrubs, such as the vine, jasmine, hazel, hawthorn, etc., are seen as undergrowth; indeed, many slopes are covered entirely with this kind of shrub, among which the cork tree (*Phellodendron*) is found. A part of the oak plantations has been destroyed by the Chinese, who fell the trees in order to collect the sponges which are attached to the bark. There is also no lack of ginseng. The meadow vegetation of central Mantchuria is distinguished by tall succulent grasses, often nearly six feet high. It would be an easy task to obtain two mowings from these meadows, but as a rule the grass which grows in the second part of the year is burnt to make room for the next crop. Besides the meadows, there are numerous marshes, which are brightened by a number of plants, among which the myriad red, yellow, and variegated lilies are the most striking, and are sure to be found in every clearing.

Among the objects of culture are millet, the chief food of the natives; maize, wheat, barley, and oats; in the south, flax and rice are found in several places; potatoes, beans, poppies for the opium trade, sesamum, kohl, leeks, garlic, and cucumbers. The principal fruit is the famous Ninjuta pear. All these productions are cultivated with the same care as the Chinese, who form the great body of the country people, were accustomed to devote in their own home. Cattle-rearing is not so extensively carried on as would seem probable from the amount of grass to be obtained; and there is only one stud near Itschen known, where the royal horses are turned out to pasture. There are few sheep, but pigs, ducks, fowls, and geese are found in great numbers. Wild mammals are very numerous, especially bears, goats, squirrels, foxes, and sables. Even tigers are frequently seen. The chase of these animals is the principal trade and means of livelihood of the small Tungusian tribes, who hunt their prey chiefly with slings and bows and arrows. Besides hunting, they are addicted to the more profitable pursuit of fishing, which is eagerly carried on by those tribes who live near the rivers, especially as they form part of a hunting tribe. For these classes the year is divided into two seasons, fishing in summer, and hunting in winter. In Sungari, the pearl fishery is carried on below Girin, but its profits are claimed as a monopoly by the Emperor of China. This pearl, a peculiar kind of grass, found in this place, and used for keeping the feet warm, and introduced into shoes and slippers, and the ginseng root, are the chief products of Mantchuria, and are held in high estimation among the Chinese.

In recent times Oppert has devoted himself to careful researches in the Corea. Surrounded on both sides by the sea, the summer heat is cooled by fresh winds, and the winter, which sets in with great severity in the northern districts, is far less severely felt in the southern and central provinces. It is obvious that a country which enjoys so fine a climate must produce an extremely rich vegetation. Besides many flowers peculiar to the Corea, almost all our European flowers are found growing wild. Among the different kinds of trees are oak, beech, pine, fir, birch, and linden. In many places one sees most beautiful plantations, which are, unfortunately, left without reserve to the good pleasure of the natives, so that large tracts of the finest timber trees are constantly cleared to make room for a field of potatoes or millet. Besides this, in the southern provinces, the cork tree, mulberry, and varnish tree are found. But in this country the uses to which these invaluable trees may be employed have not yet been discovered, and the inhabitants have not learnt, like their neighbours in the adjoining countries, to procure lac for manufacturing purposes, or silk from the numerous mulberry trees, which grow in great abundance. Moreover, the Coreans, unlike the Chinese, are no tea-drinkers, and take no trouble to cultivate the tea plant, although it grows wild in the central and southern provinces, and, with a little attention, would yield most satisfactory returns. Bamboos are found everywhere; and the vines yield finely flavoured grapes, although not the least care is bestowed upon the cultivation of this glorious gift of nature. All the fruit growing in China is found here, especially strawberries, plums, peaches, and apricots;

but since the arts of culture are so little understood, they are only found in a wild state. Besides wheat, rye, barley, oats, maize, buckwheat, and millet, the central provinces produce large quantities of very good rice, which forms the chief food of the inhabitants, beans, peas, all kinds of cabbage, and other vegetables. Cotton is found growing wild in many places, especially on mountain ridges; hemp, flax, tobacco, madder, indigo, and the best kind of ginseng. The finest quality is said to command in China the high price of £350 or £400 a pound. The larger mountain chains are frequented by many wild and carnivorous animals; tigers demand yearly their tribute of human victims; panthers, leopards, bears, wild pigs, stags, roe-deer, foxes, weasels, martens, otters, badgers, sable, and the grey squirrels, a flying squirrel, and hares. Besides these and other animals, Corea possesses animal forms peculiar to itself, which, unfortunately, Oppert did not specify. It is remarkable that the wolf, which is found in great numbers in Mongolia and the neighbouring provinces of China, is not found here. Among birds of prey the most important are the different kinds of eagles and vultures, and to these may be added a number of birds of prey known among ourselves. Wild birds are represented by myriads of ducks, geese, pheasants, partridges, and snipe. Domestic animals are rather scarce, both in species and numbers, and no one seems to have the faintest idea of cattle-breeding. The principal domestic animal is the ox, but the possession of two oxen is thought to give to a house an air of affluence, which every owner is anxious to avoid, lest his taxes should be increased. The island of Quelpart supplies the whole country with a small but strongly built race of mountain ponies. Pigs and goats are scarce, and sheep are almost unknown. Geese, ducks, and fowls, in good numbers, are seen everywhere. Both the rivers and seas near the coast are very rich in fish, and the majority of the inhabitants of the different islands make it their chief article of food. The herring fishery is very productive on the west and south-east coasts; and sardines are obtained in such numbers, that besides the immense quantities sent to the markets of the interior, they are used for manure by the inhabitants of the coasts. The pearl fishery near the southern islands is very important, and the oyster is highly prized for its fine and delicate flavour.

The flora and fauna of the island of Formosa are highly characteristic. The climate is tropical as far as the 24th deg. of N. lat., and there are only two seasons, the rainy and the dry season. The former begins in May, and ends in September, with the appearance of the north-east monsoon. It ushers in great heat and heavy showers of rain, which fall every afternoon in intermittent downpours. The dry season lasts from September to April, and during this period there is literally not a drop of rain; the sky is absolutely cloudless, and the heat almost unbearable. This regularity of climate ceases in lat. 24°. To the north of this degree the winter is accompanied with heavy rains, and the summer may be considered as comparatively dry. The result of the heavy rainfall is a most rich and luxuriant vegetation; the mountainous parts of the island are covered in the south with impenetrable jungle, a tangle of the most opposite kinds of trees, fantastically interwoven with lianas, giant ferns, and tree fern. In the north one finds large camphor forests, which are unequalled in any other country. The valleys are extremely fertile, and highly cultivated; rice, maize, millet, wheat, sugar, yams, batatas, peas, kohl, and other vegetables, yield large crops. Pineapples, bananas, ginger, betel, mango, oranges, and citrons—in short, most tropical and sub-tropical fruits—thrive admirably; the bamboo grows to a height of from seventy-five to ninety feet, and the graceful areca palm is found in equal luxuriance to its kindred in the Sunda Islands, but the cocoa palm is not found. The fauna of the island is also very rich, and has been carefully studied by Swinhoe. About thirty kinds of mammals, especially bats and flying fox, are found, among which are eleven kinds peculiar to Formosa (mole, mouse, pig, and deer). Out of one hundred and forty-four kinds of birds, thirty-three are peculiar to the island (pheasants), they are allied to those of China and Malay; as also are the rare kinds of lizards and snakes. Insects are not well represented, and are seldom seen, except in the rainy season. The western coast is exceptionally rich in fish. The domestic animals include the buffalo, an importation from China, pigs, dogs, and cats. The horse is not known; ducks, geese, and fowl are kept. Millet is used in the preparation of a slightly intoxicating beverage (*bawa*), and rice in the preparation of *samschu* or *tsiu;* tea, and as its substitute, the hot decoction of rice or batatas, are favourite drinks. Betel is in general use as a narcotic, being constantly chewed by men, women, and even children; and both men and women smoke tobacco a great deal.



Bactrian Camel.

CHAPTER III.

AFRICA.

NORTH AFRICA AND THE DESERT.

IF we except a few tracts of land bordering upon the Mediterranean, and sharing in the beneficial effects of the sea, which procures for them a vegetation like that of southern Europe, we find the whole of northern Africa covered by a trackless desert region, the outskirts of which are met in Arabia, in Hindustan, in Scinde, and Guzerat. But along the eastern margin of this desert land, the Nile, flowing from the hidden centre of the continent, has in long distant ages, during its course through the northern end of the desert, washed out a narrow valley, and formed the land of Egypt, the fair daughter of the Nile. In other countries, nature pours forth from her cornucopæia an abundance of the most varied gifts, but in Egypt she has concentrated herfavours into the one gift of water, and has presented Egypt with the Nile, the great creator and nourisher of the land, and both in times past and in the present day the very necessity of its combined existence.

The traveller who now journeys by rail from Alexandria to Cairo finds it difficult to believe that Bonaparte's army found the place a desert, and was nearly lost in its barren solitudes. The land through which the train rushes is certainly monotonous, but the constantly repeated scenery which meets the eye on each side of the line from Damanhur to Cairo testifies both to the extreme fertility of the black soil and to the industry of its inhabitants. Wide, immeasurable tracts of green fields, villages looking from afar like mounds of earth or ant-hills, and fringed with leafy palm trees and often surrounded by heaps of ruins, the *débris* of cities destroyed long ago. On the high dikes which rise above the fields, long trains of camels and asses with their drivers are seen slowly passing by ; black buffaloes descend into the water to quench their thirst, and the air is filled by multitudes of large and small birds which are far more abundant than anywhere in Europe. In one place buffaloes are seen grazing ; in another, half-naked men and women in long blue garments are working in the cotton fields. The unfamiliar pictures crowd upon us. There is the Nile! The watery network of the Delta has altered past all recognition since the days of the old Romans, and with the course of the river the vegetation which depends upon it has altered too. Not only have the ancient papyrus and the lotus blossom disappeared before the incoming of new kinds of cultured plants, but even the old corn is no longer seen, and new forms of trees overshadow the roadsides and villages. The world can scarcely contain more fruitful tracts of land than these ; but, on the other hand, few tracts make more demands upon the care and labour of the inhabitants. Only a portion of the arable land, the part called Râjefields, is overflowed and softened by the inundation. The higher-lying fields (*Sharaki*) depend always upon artificial irrigation and partly upon manuring. The fellah at the draw-well is seen oftener in Upper Egypt ; here the fields are watered by wheels to which pitchers are fastened, or wheels fitted with box-like fans. Buffaloes or camels turn the creaking machinery of the water works, and the pastoral stillness is often broken by the regular puffing and rattle of a steam pump. The water is drawn up to irrigate the cotton plantations, which are covered with flowers like wild roses, or in other places to water the fields of indigo, hemp, and corn. In varied colours, the poppy, or "father of sleep," to use the pretty Arab name, blossoms in the wide open fields ; and beds of golden globes and green fruit shew the rich harvests of gourds, cucumbers, and melons. Most of the arable land yields two or even three harvests in the year, but different seed must be sown in a certain definite succession, and in some cases the land requires intervals of rest. The huts of the poorer fellaheen are kneaded with Nile mud mixed with palm stems and branches covered with earth. Heaps of rubbish and weeds, among which cowardly yelping curs seek for their food, lie in the middle of the streets of the village, and it is not impossible to find among them the putrefying carcase of an ass. A minaret towers above the hut and houses, and the sycamore spreads out its shadowy crown as the fairest adornment of the villages. Slender date palms wave overhead, acacias scatter the bounteous fragrance of their long clustering blossoms, the stately *acacia nilotica* and feathery leaved tamarind tree (*Tamarindus indica*) have found their home here side by side with the evergreen tamarisk. The carob, breadfruit, and the children of distant India, the acacias of Letrach, which have found a home there since a few decades. Such is the Delta of the Nile, as described by Ebers. Equally pleasant and monotonous the whole Egyptian land presents itself to the spectator. It has been called "immeasurable," but this is only true of the Delta, which along the sea coast is about 180 miles wide, and decreases in a triangular shape toward Cairo. From this place to Assouan the land is only a narrow strip of sometimes two and never over sixteen miles in width. This whole stretch of more than 550 miles is deficient in that change and variety of scenery which is so much admired along the Nubian Nile, and still farther southward, where along the river all the wealth of tropical vegetation is found. The outlines of the mountain chains which border the river on both sides, sometimes drawing near the western, sometimes the eastern bank, are extremely monotonous; monotonous also is the coast scenery and the villages, which resemble each other in every detail. And yet the valley of the Nile is a lovely place, and in spite of its monotony stands out in fine contrast to the surrounding desert, and is bathed in glorious beauty when the splendours of the rising and setting sun of the eastern lands showers down upon it its wealth of light and colour. Between the red grey walls of the mountain ranges it lies as a fair garden, a life-breathing oasis between dead sand and barren rock, and its rich vegetation, blooming through the greatest part of the year, yields to its people a rich return for their care and labour. And through the centre of this valley flows the singularly wonderful street, the Nile, *Abuel-baraqua*, the "father of blessing," as the Egyptians of to-day call the river in their gratitude.

Towards the end of June, when the river is at its lowest, it begins to rise again near the falls of Assouan. At Cairo the eagerly looked-for event occurs in the beginning of July, and the river gradually rises from about twenty-three to fifty feet. If between the 20th and 30th of September the water has reached the height of fifteen ells, sixteen kirtâ, the sheikh announces the happy event to the expectant population, the piercing of the dikes is begun on all sides, and the life-giving stream rushes over the thirsty fields. But this desirable height is not always reached, and the prospect of coming famine is then the inevitable result. It is not to be wondered at that the priests of old days taught that a tear of the goddess Iris falling into the Nile was the cause of the inundation, or that the Egyptians of to-day speak of the "divine drop" which falls into the river and causes it to rise, while Baker tells us that the rainfall of Abyssinia causes the rise of the Blue Nile, and all the consequent beneficial results.

"The Blue Nile," he says, "is so low during the dry season, that it is not navigable even for the small boats used for the transport of goods from Sennar to Khartoum. At this period the water is beautifully clear, and as the river reflects the blue sky, its colour has obtained for it the name of Bahr-el-azrak, or Blue River. There is no water so delicious as that of the Blue Nile; it is a thorough contrast to that of the White River, which is never clear, and has an unpleasant vegetable taste. The Atbara, although it is an important river in the rainy season of Abyssinia, is perfectly dry for several months in the year, and on the 15th of June, 1161, when I saw it, was a bare plain of shining sand—a mere portion of the desert through which it flows. From the beginning of March up to June it is dry for the space of about 135 miles. At long intervals water is seen left in the pools and deep holes which lie below the average level of the river bed. In these holes, many of which are several miles long, all the denizens of the river crowd together, and as the river disappears find themselves obliged to live in close quarters. Thus we find crocodiles, hippopotami, fish, and large turtles assembled in great numbers, until the beginning of the rainy season in Abyssinia sets them free, by sending down fresh masses of water to the river. The rainy season begins in Abyssinia about the beginning of May; but as the land is scorched up by the summer heat, the first showers are absorbed by the soil, and the waterfalls do not begin to fill until the middle of June. From June until the middle of September the storms are terrible; every ravine becomes a roaring torrent; trees are uprooted by the mountain streams which overflow their banks, and the Atbara becomes a mighty river. Its waters are muddy with the rich loamy earth washed down from the most fertile lands; masses of bamboo and driftwood, and many carcases of elephants and buffaloes, are hurried onward by its resistless waters, in wild confusion, and the inhabitants of the banks, who keep on the look-out for its treasures of fuel and valuable wood, reap a rich harvest from its waters.

"During the year I (Baker) was in northern Abyssinia and the adjoining countries, the rain lasted for three months; the last shower fell on the 16th of September, and from that day until the following May there was neither dew nor rain. The Atbara disappeared, and was again transformed into a plain of glittering sand."

The country of the Nile presents a singular appearance after the piercing of the dikes. It does not resemble a great lake, as we so often hear it described, but is rather covered by sheets of water bounded and hemmed in by numerous dikes. In some places the land is left dry, and only single fields are submerged weekly or monthly, according to the pleasure and need of their owner. When the sluices are shut, the water soon evaporates, and the field is ready for the plough in a few days. High water lasts for about fourteen days, and then the river gradually goes down, leaving behind it a stratum of rich mud, the "red soil" of Egypt. The seed is generally sown in this earth, but the productiveness could be much increased by the judicious use of manures. The period of inundation is a crisis also in the life of the animal world. The cattle are turned out of the low-lying pasture lands, mice and wild creatures are driven from their hiding places, and forced to seek higher places of shelter. Insects, worms, lizards, and such-like creeping things try to escape to the dry land, but are generally drowned at last. Graminivorous birds, especially pigeons, no longer find their accustomed food, and wander in long flights to the desert, to follow the tracks of the caravans. But the waters are full of life; countless fish, frogs, and aquatic insects abound, and water-fowl flock to the banks and islands of the river.

The principal vegetable objects of culture are wheat and maize, to which must be added millet (*Doura safra, Sorghum vulgare*) in Upper Egypt, and rice in the Nile Delta. Rye, millet, and oats are scarce; barley is largely grown, but only as fodder. More than fifty varieties of cotton are known; the best, according to the official reports, covered in the year 1175 a tract of more than 800 square miles in Lower and Middle Egypt alone. Indigo and madder are found but seldom; sugar-cane, tobacco, and poppy (for opium), saffron, and henna, are largely grown. The dried and pulverised leaves of the henna plant (Alkanna, *Lawsonia alba*), a shrub resembling the *Lingustrum vulgare* in shape, is used for dyeing leather, and for staining the nails, fingers, hair, and toes a yellow colour. Hasheesh is in constant use, although forbidden by the authorities.

"All preparations of hasheesh," says an official report, "have as their chief ingredient a sticky substance, which is nothing else than butter boiled until it has absorbed the gum substance of the hemp plant. The Arabs prepare several confections from this extract, adding sugar, honey, almonds, or different aromatic ingredients; they bake it in little cakes, or turn it into a syrup, which is thick enough to harden into a solid substance as it cools. The misuse of this voluptuous and enervating preparation has rightly called forth a prohibition of its use. But in spite of all prohibitions the Egyptians are as addicted to its enjoyment now as they have always been; and not only the Egyptians, but two or three millions of people distributed over the whole of Africa, Turkey, Persia, and India are held under the sway of this deleterious and most unpleasantly tasting drug, which is called by them the 'increaser of joy, the awakener of desire, the tie of friendship, and the exciter of laughter.'"

We need not now enumerate the numerous vegetal, tuberous, oil, and fibrous plants cultivated. Most of them are immigrants, as shewn by their Egyptian names. Thus, the potato is called *patatis Americi*; sesam, *semsem*; flax, *kettan frangi*; and jute, *tyl indij*. But especially characteristic plants are the gombo (*Hibiscus esculentus* and *Hibiscus bammia*); several kinds of mallows, cultivated also in Asia Minor; *Corchorus olitorius*, an allied plant to jute, and tasting like spinach; kulkas, or *Arum colocasia*, which tastes like a potato; the egg plant (*Solanum melogena*), and tomatoes (*Solanum lycopersicum*), while potatoes are scarcely cultivated at all. Among fruits we find bananas, pomegranates, figs, grapes, olives, opuntias, oranges, breadfruit, or carob (*Ceratonia siliqua*), and others are objects of culture for the market; and last, but not least, the *date*, or fruit of the palm tree. It must be noticed, however, that the climate of Lower Egypt is too hot for many of these plants, so that their fruit is small and of little value there. Thus lemons and oranges produce insignificant fruit, and apples, pears, quinces, peaches, and plums really belong to a colder climate, and although often planted, do not succeed to any great extent.

The date and the camel are here inseparable. "The palm is the camel, and the camel is the palm of the desert," is the often-repeated saying of the dwellers in the desert; and with reason, for the desert could scarcely be imagined without these two accompaniments; and yet the camel, although it is so frequently seen on old monuments, was not used in the time of the Pharaohs; and the Carthaginians traversed the desert in every direction without making use of camel or dromedary. Indeed, it was not in general use until comparatively recent times, being brought by the Arabians in great numbers to the Nile. It is true that the camel is easily acclimatised, wherever it finds the requisite conditions of its existence. After the Crimean war the Tartars and their camels wandered into the Dobrudscha, and Kremer found them perfectly at home there, and saw them drawing the carts of the Tartars across the frozen Danube near Galatz.

The two characteristic plants of ancient Egypt, the papyrus and the lotus, are generally sought for in vain in Lower Egypt. They have been gradually forced to give way to the levelling power of modern civilisation, but they are still found in abundance upon the banks of the upper course of the Nile. The famous paper plant of the ancients (*papyrus antiquorum*), a graceful rush, from fifteen to eighteen feet high, was formerly carefully cultivated for the paper from which it receives its name. The paper made from rags has long ago supplanted the papyrus paper, the once costly writing material of the Pharaohs, and the plant is only cultivated as a rarity. The same fate has befallen the lotus plant, a kind of water rose (*Nymphea lotos*), nearly connected with our own white water lily. The ancient Egyptians looked upon it as the symbol of plenty, and dedicated it to the gods Isis and Osiris, but now its sacredness has disappeared, together with the taste for the detestable bread made from its seeds.

In Upper Egypt, Nubia, Sennar, and Kordofan we find the cassia plant (*Cassia obtusifolia*), the leaves of which come into the market as the senna of Alexandria and Tripoli; but the home of the Indian, Arabian, Mecca, and Bombay senna (*Cassia angustifolia*) extends along the whole eastern coast of Africa from Upper Egypt to Mozambique, Arabia Felix, and Hindustan, whence the Syrian senna and that from Aleppo (*Cassia obovata*) is also obtained.

The seyal acacia, one of the principal plants giving gum arabic, is a native of Upper Egypt, and is also found in the deserts of Libya, Dongola, and Nubia; about a dozen kinds of this gum arabic are exported from Egypt. Another indigenous plant is the zizyphus (*spinæ Christi*), with its small olive-like fruits. The only palm found here by the side of the date palm is the doom palm, which must conclude our list of Egyptian plants.

This palm (*Hyphæne Thebaica*) begins on the threshold of Upper Egypt, and extends southward as far as the highland plateaus of Abyssinia. In the northern districts of their distribution the palms are found singly, growing more in groups towards the south. Its northern boundary in Egypt is found in lat. 26° N., while in Arabia it is found as high as lat. 28°. The singularity of its growth is that its high stem is forked at least once, so that it loses to a great degree the characteristic type of the palm tribe. It reaches the height of thirty feet, its fan-shaped leaves sometimes six feet long. In many places it is almost the only tree found,and for that reason, as well as from the fact that the rind of its pear-shaped fruit is extensively used for food, it is of great importance to the country. The taste of the fruit is not particularly good; indeed, it has been compared to an unbaked gingerbread kneaded up with a toothbrush. In spite of this unfavourable verdict, it is eaten with much relish by the fellaheen of Upper Egypt, and forms a nutritious food in the hungry desert land of Tibesti, where, however, it has to be carefully made eatable by bruising it with stones. Its hard kernels are used for turnery, and its leaves provide material for ropes, carpets, and baskets; but this fact is scarcely singular in a land where the palm supplies almost every need of the inhabitants, failing them only in the matter of fuel; indeed, the scarcity of wood throughout Egypt is so great, that dung is used almost everywhere to supply the lack of firewood.


Doom Palm of Egypt (*Hyphæne Thebaica*).

There are few uncultivated plants, for the country has neither mountains, forests, heaths, nor meadow land, being divided into arable and fallow land, steep uncultured river banks, hedges, and channels for the river inundations. Where the sway of man is not owned, there are, it is true, many plants to be found, but they are generally isolated, and even the grasses, of which there is a great abundance, do not form a connected carpet of turf; the only substitute for meadows is the clover field, which is used as a pasture ground. Moreover there is an absence of fresh green: the great majority of the plants are dry, stiff, and prickly, hairy and downy; even the flowers lose their most vivid colours, and there are no bright-coloured orchids.

We have already spoken of the camel, or one-humped dromedary, which holds so important a place in the fauna of Egypt; next in value is the insignificant-looking but useful ass, compared with which the horse ranks in quite a subordinate capacity. A short time ago Egypt was rich in horned cattle; but the plague of 1863 and the succeeding years has almost annihilated the long-horned breed which is seen depicted on the monuments. Foreign breeds, such as the oxen of Soudan and the imported European breeds, are difficult to acclimatize, and are said to be ill adapted for the purposes of agriculture, as was found to be the case with the zebu in old times. Happily both the buffalo and the sheep escaped the cattle plague; the latter forms the principal food of the richer classes, as the goat does of the poorer. Like the Jews, the Mahommedans look upon the swine as unclean, and it is rarely found in Egypt.

A half-wild dog, closely akin to the jackal, is found in every part of the country, and the cat, of which the Egyptian and Nubian *Felis maniculata* is considered to be the primitive ancestor, leads a semi-wild and marauding existence. In the desert, and among the ruins and fragments of stone scattered along the banks of the Nile, the striped hyæna is not an infrequent visitor, but it only appears in inhabited districts at night to seek for carrion. The jackal haunts also the outskirts of the desert, and its grim uncanny howling is heard through the night and at the break of day mingling with the bark of the dogs, whose duty it is to keep off the marauder from the poultry and the sheds of the smaller cattle. The Nile fox (*Canis Nilatica*) is another sworn foe of the poultry yard, and is often captured in the gardens at the time when the grapes ripen. In the deserts of the west it is represented by the small-eared fox, or *fenek*, and in the eastern desert by the kindred type, *Canis famelicus.* Beasts of prey are sometimes found; such as the marsh lynx, wild cat, a few kinds of jackal, and genet. The wild boar and ichneumon (Pharaoh's rat) belong to Lower Egypt. It is perhaps scarcely necessary to mention that the stories so constantly found in Pliny's narratives concerning the latter animal, that it carefully approaches the crocodile as it lies sleeping with open jaws, and, suddenly springing down its throat, bites the heart of its enemy, and gnaws out a passage thrôugh its body, also that it steals the crocodile's eggs, are entirely fabulous. The ichneumon eats what it can get, and robs all that comes in its way, mercilessly attacking hens' nests, dove cots, and birds' nests. The most common antelope found in the desert, and sometimes also upon the banks of the Nile, is the gazelle (*Antilope dorcas*). The hare is frequently found, the hedgehog less often, but the porcupine, so often represented by the ancient Egyptians is all but extinct. Even the once sacred hippopotamus, or horse of the Nile, has long been banished from Egypt proper; but its presence in the districts of the Upper Nile it is impossible to forget while the scourge used to punish criminals, and made of the skin of this animal, is kept in such constant activity by the servants of the government. Mice and rats are very abundant; and the large field-mice are considered a great delicacy by the peasants. A shrew-mouse, once held in honour by the ancient Egyptians, is also found. Rats frequent grottoes, old temples, and graves, in many varieties, each of which is very largely represented. One of the most interesting is the "date-eating" not "blood-sucking" vampire (*Pteropus Ægyptiacus*). Apes, which were held sacred by the ancients, and which, especially baboons, are often represented in the books of death holding scales or sitting on the cross beams of the scale, are never found wild in Egypt proper, but it may be that they have been also rooted out in the long time which has gone by since the paintings were discovered.

The inhabitants of the Nile are far less characteristic than is the river itself; for out of its thirty-six kinds of fish, twenty-six are common to the west coast of Africa, and five or six to the east African waters. Crocodiles are now only found in Egypt in the caves of the Maabdes, where their mummies are stored up in thousands. The most remarkable fishes are the fahak (*Tetrodon fahaka*), bichir (*Polypterus bichir*), and the electric silurus (*Malapturus electricus*).

The fahak is about ten inches long and very vividly coloured. It belongs really to the Mediterranean region, but is more often seen and captured in the Nile; it has the singular quality of swallowing a large quantity of air, and inflating its body like a ball. Old and young delight in its appearance, and the children play with it as ours do with beetles; they drive the inflated bubbles along the water, expand them, and when they are dried, use them as balls to play with. Travellers buy them often, and carry them away as curiosities. The bichir is described as a fish with from sixteen to eighteen dorsal fins, each of which has a spear and several rays, and a scaly covering shaded from green to dirty white, which renders it impossible to divide the fish even with a knife. It is a large fish, about twenty-four inches long, and belongs to central Africa, being abundant in the White Nile, and coming down into Egypt with the high tide. The electric silurus can give out electric shocks like those of a galvanic battery. It can be sometimes handled without the person who touches it receiving an electric shock, but at other times the fish shews signs of its displeasure at the slightest touch; indeed, it will sometimes allow many persons to hold it, and then it gives a sudden shock to the next who touches it. The shock is not painful, and can only be dangerous to very small creatures.

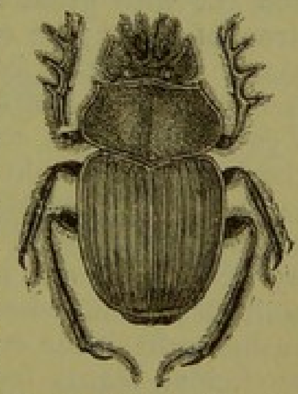
Numerous other fish which the Nile contains, such as barbel, carp, sheatfish, salmlet, and also salmon (*characinidæ*), river wrasse (*chromidæ*), and Nile pikes (*mormyrida*), to which we must add mullet (*mugil*), a fish belonging to the Mediterranean, a sort of herring (*clupea*), and eels, are less worthy of interest; but both they and the immense number of worms, frogs, crabs (*telephusa*), shrimps, snails, and fresh-water mussels, and insects, whose life depends upon the inundations of the Nile, offer abundant food for the large numbers of birds. Flocks of herons, flamingoes, and pelicans rise in clouds, and darken the air; Ebers assures us that it is no exaggeration to say that the aquatic birds, as represented in a picture of Lake Mensaleh by Gentz, are crowding one another from the surface of the waters.

"I looked across the wide lake of Mensaleh," writes Brehm, "and upon thousands and thousands of birds, literally hundreds of thousands. The eye remained fascinated by a long line of fire, of wondrous, indescribable splendour. The sunlight played upon the dazzling white and rose-red colours of the birds, and brought them into vivid intensity. Startled by some sight or sound, a swarm arose from the tangled chaos, and from the living roses a long procession of flamingoes formed in the triangular lines affected by the cranes, and once again the line of fire crossed the blue sky. It was a glorious sight. Slowly and gradually they sank earthward, to rise again in their accustomed order, so that I fancied a regular body of troops was preceding me." The birds here described by Brehm are flamingoes (*Phœnicopterus roseus*); the spoon heron (*Platalea leucorodia*) and the pelican (*Pelecanus onocrotalus*) are also described by the same writer. "Along the shores of the Egyptian lakes, on the waters of the Nile, during the period of inundations, or far down in the south, on the White or Blue Nile and its tributary lakes, as well as upon the Red Sea, pelicans are seen in such numbers that the eye cannot distinguish a single group. They literally cover it to the space of several square miles, and look, when resting upon the waters, like gigantic sea roses, or, when ranged upon the shore or islands to plume their wings, they may be taken for a long white wall, or again, when settling down to sleep upon the trees, they lie so close that it seems as if the trees bore no leaves, but were covered with large white blossoms. It is an unusual sight to see flocks of ten or twelve, but troops numbered by hundreds and thousands are common. Towards the spring the flocks are in a measure dispersed, because at that time many of them go to the south of Europe and breed there, and even those which remain in Egypt and North Africa cannot find breeding places large enough to allow them to build their nests in troops. But large numbers of young birds are seen in flocks." It is clear that the aspect of these places is in no way different from that of the breeding places in southern Europe. "These places," writes Count Von der Mühle, "can only be approached with great difficulty; they are found on floating islands, and the damp, moist nests stand closely pressed together upon the humid soil. The nests are made of coarse sedge or reeds, and the whole place is covered with thin, white, liquid manure and rotten fish, from which rises an indescribable, intolerable, and pestilential stench."

A no less frequent visitor is the elegant little silk heron (*Ardea gazetta*), with the cow heron (*Ardea bubulcus*), while the night falcon (*Ardea nycticorax*), the fishing heron (*Ardea cinerea*), singing swan (*Cygnus musicus*), and others, spend at least the winter-time in the blessed land of the Pharaohs. The heron (*Ardea bubulcus*) belongs to the commonest birds of the Nile lands; its home extends from Egypt throughout all Africa, including Madagascar and the western shores of Asia. Unlike most birds of the heron tribe, it builds near towns and villages, even when they are at a distance from the water. Its favourite places of abode are fields which have been laid under water, but it is occasionally found upon the banks of rivers, canals, and lakes, and it was seen by Heuglin on the shores of the Red Sea, on desolate burning cliffs. In the steppes it comes in by hundreds and thousands, when the locusts make their appearance; and even in the desert it is seen now and then, seeking the beasts of burden which traverse its solitudes. It loves to perch near or even on large animals, in Egypt upon buffaloes as they graze, and in Soudan upon elephants. It takes up its position upon their backs, and feeds upon the various insect pests which plague the animals; and that is the cause why it is so frequently seen upon the backs of wandering herds of elephants. Sometimes from eight to ten of these graceful snow-white birds are seen standing upon a single buffalo, and it must be owned that they add very much to its appearance by their graceful presence. The bird is on equally friendly terms with the natives; he knows that he is a welcome guest in the land, and that no one will molest him, and accordingly he runs to and fro among the peasants in the fields, as if he were a house pet. Even the dogs offer no resistance when the bird perches upon their backs to seek for insects. Insect hunting, however, does not occupy the heron's attention so exclusively as to prevent him from making a meal now and then of an occasional reptile or a small fish. Most of the commoner varieties of birds, of which about 300 have been classified, are birds of passage from Europe which take up their winter abode in North Africa, and assemble there in immense numbers. Indeed, if these migratory birds were not included in our estimate, the numbers would be considerably reduced; for instance, in Malta, which affords a resting place to 278 varieties of birds on their crossing the Mediterranean, there are only eight *resident* land birds and three water-fowl.

Of the vulture tribe, we find the white-headed vulture, the eared vulture, and the little carrion vulture, or Pharaoh's hen; all of them ugly but extremely useful creatures, since the clearing away of all the carrion is left to them. Falcons are kept for the chase, as they used to be by ourselves in the middle ages, and the cry of the kite is heard everywhere. Characteristic birds are certain night and wall sparrows, our hoopoos are frequent, while wood-peckers are unknown; what, indeed, could they find to do in a treeless land? Hooded larks, sparrows, swallows, and wagtails are common. There is a great dearth of singing birds, for the sweet-voiced migrants only spend the silent winter months in the Egyptian land, so that the only singing birds belonging to the country are a nightingale and the stone-chat. The shrill sand-grouse (*Pterocles*) is found in the Nile valley and in the desert. Quails appear in dense swarms as birds of passage. Among the representatives of the bird world most frequently depicted upon the old Egyptian monuments, the stately Nile goose of Lower Egypt is rarely found, and the sacred ibis is unknown; both of them have been driven back towards the upper course of the sacred river, where they are still abundant. Fowls and doves are very generally kept. The propagation of the former was forwarded by the use of hatching ovens (which were thoroughly understood by the ancient Egyptians), and these ovens have houses built for them in every village, often roomier and more elegant than the dwellings of men. The reptile tribe is represented here by some of its most distinguished members. The monitor-lizard crawls along the river banks; the mountain-monitor frequents the desert; a beautiful turtle (*Trianyx niloticus*) lives in the Nile. Along the furrows and trenches, nimble bright-coloured lizards bask in the sun, and the slippery skink (*Scincus officinalis*) burrows in the wall of almost every house. Along the walls of the houses dart and glide the nocturnal little gekkoes, the greedy but otherwise inoffensive "fathers of leprosy." Here and there upon the trees is seen the changeful play of colour of the familiar chameleon, while the earth agamas and other reptiles, often brightly coloured, and some of them more than a yard long, love the desert solitudes. Egypt was always famous as the land of snakes. It has about twenty varieties, poisonous and non-poisonous. As in the days of Moses, so in our own times, there are a large number of snake charmers; the snakes which they use in their performances, especially the once sacred viper, urau snake, and Egyptian spectacle snake (*Naja haje*), are always first deprived of their fangs. The snake most frequently depicted by the ancients is the very deadly and dangerous horned viper (*Vipera cerastes*).

In the great insect world Egypt has many forms which are known in southern Europe, and some, especially in Upper Egypt, which are distinctly African. Day butterflies are scarce, while moths are more abundant. The beetles are not exactly numerous, but among them are some very fine specimens of brilliant beetles (*Buprestis*), sand beetles (*Cicindela*), and dermestes. The commonest are the blackbeetles and the dung beetle, but the best known of all is the sacred scarabee beetle (*Ateuches sacer*), the scarabeus of the ancients, which is so frequently represented upon monuments and gems.

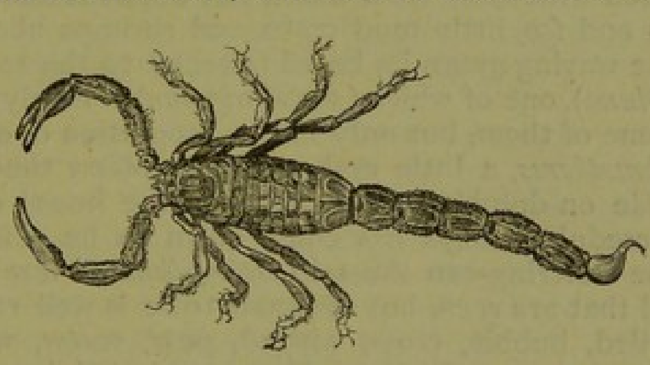


Sacred Beetle (*Ateuches sacer*). Natural size.

A characteristic scene of animal life, often to be observed both in Central and South Africa, are the manœuvres of a company of these droll little creatures busily employed near a dung-hill, rolling up the dung into globes as large as a walnut, pushing and thrusting each other aside until the great business is completed, and then, with their heads bent down to the earth, rolling away the work of their feet to bury it in a convenient place. The beetle, which is rather more than an inch long, rolls up these balls to feed its young, and deposits its eggs in them. In the theological symbolism of the ancient Egyptians, these "pills" were compared to the substance of which the world was formed, and which was also represented as globular. The beetle itself is looked upon as the principle of light and creative force, which, in union with the disc of the sun, infuses into matter the germs of light and creation, as the beetle deposits its eggs in the dung ball. The deity Ptah (that is, the forming and impelling force) then gives to these germs their form, and creates the heavens and the earth.

The wasp tribe is also represented by many fine and large varieties. The Egyptian bee is nearly akin to our own, and has often been introduced into Europe. Ants, locusts, and cockroaches are at times great pests, while the termites are not yet thoroughly acclimatised. The common house-fly is nowhere more bold and importunate, and succeeds only too completely in rendering an otherwise pleasant life most disagreeable. The stinging gnat is just as bad, and its unceasing hum is almost more calculated to drive a new-comer to despair than its painful, burning sting. At certain times its worm-like larvæ abound in all standing waters, swarm in the drinking water, which can only be drunk when strained through a cloth, or, as is the usual practice with the poorer classes, through the coat-sleeve held between the pitcher and the lips. Vermin are only too abundantly represented; fleas, bugs, and lice of every kind abound, besides scorpions, tarantulas, centipedes, and leeches, and those implacable tormentors of animals, horse-flies and gnats. The monotonous character of the whole country is perceptible throughout its flora and fauna, for in almost every class of the animal world the number or varieties is comparatively small.

We now turn our attention to the country lying eastward toward the Red Sea. The path lies through a desert, which is not, however, wholly destitute of vegetation; where, after abundant rain, the valleys are transformed into verdant pasture lands. The flora is most abundant from February to April, but the almost tropical heat destroys one plant after another, leaving only the more deeply rooted growths for the summer months. The plateau-like western portion of the desert resembles, both in its appearance and vegetation, the Libyan desert, and is very poor in vegetable life. By far the most common plant of these regions is the desert bramble (*Zilla*), a half-shrub, with flowers like its kindred plant, the radish; it is this plant especially which, when seen from afar, gives to the valley the appearance of green meadow-land. The wise Egyptian ass, notwithstanding the preference shown by his European kindred for thistles, is prudent enough to keep at a respectful distance from this plant, which the hard-mouthed dromedary can eat with great relish; chewing the prickly masses without losing one drop of blood; he even swallows with delight the thorns of the acacia. In many places the *leptadenia pyrotechnica*, a plant resembling broom, grows freely; it is a long-branched, almost leafless bush, much liked by camels. Zygophyllum is a common but very salt desert plant, which is only eaten by the hungry Bedouin camels; it grows in the driest places, and in the most rainless years, and yet is full of sap. The ill-smelling bush of "stinking cleome" is avoided by all cattle. Shadowy groves of tamarisk, frequented by many birds and insects, often surprise us in the midst of the most barren solitudes; and wherever the soil has received any moisture, willows and rushes refresh the eye of the traveller. Cassia ranks high among the list of medicinal plants found in the desert, and colocynth (*Citrullus colocynthus*), with its creeping cucumber-like stems, filled with fruit resembling our apple, first green and then turning yellow, is found along all the outskirts of the valleys. The natives have a wholesome awe of the drastic remedy, and scarcely ever touch the gourd fruit; while the Bedouins remove the inside pith and seeds, and fill it with milk, to take it next day as a remedy. The desert flora is not quite destitute of edible fruits. The date palm, it is true, is seldom seen, and then only in a half-wild state; but the *balanites* and a fig tree (*ficus pseudocarica*) are found laden with fruits. The fruit of the caper tree tastes like an odd mixture of sugar and mustard; and the traveller is refreshed by the pleasant acid of the sorrel, the berries of the lycium, a thorny plant, and those of the creeper *ochradenus*, and the saltpetre shrub, a bush growing near the coast (*nitraria*); indeed, the parched tongue does not disdain the buds of the above-named leptodenia, which look like cherry stalks, and taste like prussic acid or the milky fruit of the *glossonema*. The coast flora of the desert is very peculiar, and depends upon the salt vapours rising from the sea. The dense woods of the shora (*Avicenna officinalis*) are famous in travellers' descriptions; they stand out in the sea itself, and are only dry at low tide. Ships are laden with its wood, which is used for fuel, and many camels live entirely on its great laurel-like leaves. The coast is covered in some places to great distances by the above-named saltpetre shrubs, and by many other saline plants, *Salicornia*, *Statice*, the soda plant (*Suæda*), and the cyperus grass (*Cyperus*). In favourable years it is an easy task to fill an herbarium with 100 or 150 kinds of plants; and therefore, in spite of the great difficulties of existence, the desert is the chosen home of a large number of animals of different classes. Insects are often found; and among them the most interesting is the sacred *Mantis religiosa*, or "mare of the prophet;" ticks and scorpions are found everywhere. Snakes large and small, venonous and harmless, are well represented, together with lizards, agamas, warans, and gekkoes. The eared vulture hovers overhead "in the eye of the sun," often sweeping down in dozens upon a heap of carrion. The carrion vulture is much commoner. But the typical bird is Noah's raven, the *Corvus umbrinas*, believed to have been banished from the ark. No man can shoot this bird with impunity, for it is "the uncle of the black Soudans," who always demand the inevitable blood money for their slaughtered kindred. Other characteristic birds of the desert are the wild hen (*Ammoperdix*), the sand-grouse (*Pterocles*), the desert-lark (*Ammomanes* and *calandrites*), the stone-chat and (but very seldom) the ostrich. No well is seen without our common wagtail; the swallow haunts the tamarisk groves, and the hoopoo is often seen. The rock pigeon builds its nest on the rocks above the pathway of the caravan. The running bird (*Cursorius isabellinus*) belongs half to the shore, and half to the desert; like most of the desert creatures, it is of a greyish yellow colour. In winter-time the shore is alive with flocks of aquatic birds. No pleasant musical bird voice is heard in the desert, but the twittering of the stone-chat, the "peep" of the desert larks, the hoarse cry of the ravens, the shrill scream of the birds of prey, and at night the weird, ghostlike hoot of the owl.



SCORPION (*Buthus occitanus*). Natural size.

The largest and most dreaded mammal is the striped hyena. This animal, however, is not nearly so bad as its reputation would lead one to believe; it is almost unheard of in the desert for the hyena to devour men or even children. Carrion is its favourite food; and when this fails, it prowls down to the sea-shore and breaks open sea shells. The lynx (*Felis chaus*) is rare; the fox, on the other hand, is everywhere; the jackal is only met with on the western borders of the desert towards Egypt. Hares, shrew-mice (*Dipus*), and land mice appear chiefly at night. The hyrax is a pretty little animal very difficult to capture. Only one kind of antelope (the gazelle, or *Antilope dorcus*) is found, but that is very abundant. The ibex (*capra behen*) is tolerably common. The African wild ass (*Asinus tæniopus*) is probably found in all desert lands eastward of the Nile, to the coasts of the Red Sea, and is easily distinguished from its tame kindred by the black stripes of its legs. Dromedaries, asses, sheep, camels, and goats, are creatures tamed to the service of men in the desert.

On the western coast of the Red Sea lies the seaport town of Upper Egypt, Cosseir. Why the sea is called red is difficult to imagine, for there is hardly anything red about it. The shore and the land far into the interior is the most desolate and unattractive waste, but the sea is full of life and interest. The broken rocky surface of the shore, with its thousand points and capes, is no ordinary rock, but a composite patchwork of limestone, mussel shells, worm pipes, and above all coral blocks. The margin of the reef lying farthest from the sea is only submerged by the life-giving waters during a few hours in the day; and the water left in the holes becomes so hot that if the naked foot is dipped in it is drawn back at once; and in some days of the year, when the flood tide does not reach them, the sea water remaining unchanged by the waves reaches such a high temperature in summer, and falls to such a low one in winter, that the fish in it dies off in shoals. Young fish, sea-groundlings (*gobius*), and springers (*salarius*), large-eyed crabs (*macrophthalmus*), mussels, shore snails (*litorina* and *cerithium*), a purple snail (*purpura hippocastanum*), the limpet, moon, and beetle snails (*patella, nerita*, and *chiton*), are found in abundance. The holes and rifts of the porous stone offer hiding places to the winter crab (*Gelasimus tetragonon*). In sandy pools one sees a number of little hills and holes, each of which has its peculiar use and meaning; in one dwells the worm (*terebella*), and in the other the crab (*alpheus*). The fine thread-like seaweed and the pale green broad-leaved weed (*phycoseris*), together with the shorea bushes, are covered with numberless microscopic bright-coloured cyclops and snail brood. Advancing farther onward, we find ourselves in the belt of sea grass. The pools are more filled with sand, from which rise different lichens. Snails of every kind creep to and fro, little mud crabs and shrimps abound. Deep in the sand below the waving grass, its beard fastened to the rock below, lies the fragile mussel (*pinna*), one of which (*pinna nigrina*) is nearly twenty-four inches long. Inside some of them, but only in the proportion of one among thirty, is the famous *pinnotheres*, a little crab which in olden times, when poets and singers still rode on dolphins, used to guard the house of the blind *pinna*, but in these incredulous days has come down to be a mere parasite. Shells are rare; the watering-can mussel (*aspergillum*), a few venus, ark, and heart shells are all that are seen, but the snail tribe is well represented: harbour snails, side-gilled, bubble, cross, winged, pear, screw, weel snail, and other still more singular ones, fill the collector with delight. In rifts and fissures are found the grey, brown, and black starfish (*ophiacoma*), and the sea-urchins peer out from their narrow holes.

Passing onward from the belt of coast land, we come to a second important zone, that of the coral algæ, beginning with a moss-like weed which covers the rock like a soft carpet. The pools have become larger and deeper, sometimes appearing almost like wells. Characteristic coral algæ (*corallina*), and the first coral, the styloid or *stylopora*, appear. Here indeed are collected creatures which love pure, cool, and still water. The starfish become more numerous and varied, for the *chama* shells are seen fastened to the rock by means of lime secretions; the green, piebald hermit crabs, the pearly Pharaoh's snail (*monodonta Pharaonis*), lovely little dove shells (*columbella*), nipple shells, scarabee snails, and murex are found on all sides. In the shallower depressions fine sea anemones (*Cereus* and *Heptakis*) abound. We have but to lift up a stone which lies rocking loose in a pool or streamlet—how full of life we find the waters and the stone itself! The upper surface is generally thickly overgrown with algæ, upon whose mossy crests are seen, side by side with minute sea crabs, the wonderful little horned crabs, *menæthius, pisa*, etc. The rough hairy shell and the feet of these singular types have become a perfect harvest-field of luxuriant seaweed, or if smooth and flat, they take the prevalent colours of the plants between which the crab wanders to and fro, changing in one and the same type from dark brown to vivid emerald green. But the *Dromia* crab manages still more cunningly than even this imitator of its dwelling and surroundings, for it clothes its bare back, which is only lightly covered with downy hair, with sponges or algæ, holding them up stiffly on its outstretched hind claw, and so deceiving both its greedy enemies and its unsuspecting victims. By its side we see the small and medium-sized arch crabs, of which the Red Sea is so full, besides sponges, sheaths, mosses, worm shells, joint, tape, and tube worms, numerous snail and other shells with oyster and pearl shells, and everything is covered with the tiny shells of minute sea creatures. The collector begins at once to swoop down upon the welcome booty, but the crabs are in no haste to be caught. Yonder, a worm (*Notopygus*) shoots out its silken hair-like tufts of prickles, which pierce the skin with their hooked extremities, creating a tingling pain like the sting of a nettle. A long, round, rose-coloured joint worm (*dasybranchus*) breaks up into fragments when it is touched or even disturbed; while the *syllis* is still more sensitive, and even by daylight flames out limb by limb in dazzling blue or green. The starfish quickly frees itself from the hole which has been made with such difficulty, lets itself drop, and creeps off into the nearest hole that it can find, caring little if it loses a claw in the process, as it can easily obtain a new one. The pinna breaks into pieces, unless we have first carefully released its beard; and numerous specimens having once slipped from our hands are lost altogether, thanks to their power of shrinking into a small space.

A massive block of stone lies perchance in a shallow depression of the reef. We roll it away, a few small fish hurry away, but we find some large langousts (*Palinurus*) and also many of the above-named creatures, and a few beautiful though common snails (*Conus*). Here, too, lurks the red brown octopus, which, as soon as it is discovered, darts away, and in cases of extreme danger stains the water black with its inky fluid. It is not easy to secure the strong slippery creature, and the clinging of its feelers to the skin is unbearable. The margins of the rocky edges of the pools, which are often about a yard deep, are overgrown with algæ of every kind, flat encrusting weed, high, bushy, and soft mossy weed, rough or stony, green, brown, and reddish weed, moss and fern-like, fruit-bearing and non-fruit-bearing weeds. Here and there waves a tuft of *stylopora,* sometimes yellowish or brown, sometimes reddish. Within the rocky walls of the pools shine wonderful blue points and curves, flecked with green and brown, and measuring four or five inches in width; they belong to the large shell fastened tight between the rocks, the *Tridacna.* Half hidden, we see black brilliant balls, from which protrude fine spearlike lances, while upon the surface of the balls shine sky-blue quivering lines and dots; at one end of the ball revolves a black club-like creature, with a vermilion border at one end; it is the diadem sea-urchin, which is as beautiful to look at as painful to feel, when its pointed fragile prickles are seized, and the sharp burning sting of its microscopic thorns revenge the attempted capture. Lying quietly beside it is the suicidally inclined olothuria, the cylindrical synapta, the comb-star *asteropecten*, the sea-turban (*cidaris*), and other prickly sea beasts.

Still farther seaward, a tract of different corals, star, porous, spotted, and the well-known purple-red organ coral, leads us to the true belt of the reef coral. The ground is now changed into a slippery desert of seaweed, and between the luxuriant plant growth the naked foot is everywhere menaced by the tube of the tube-worm drilled into the rock. Nine forms of the previously mentioned starfish and crabs appear. A giant form of the latter (*Pagurus tinctor*) is often found in the larger snail shells—for instance, in the ton shells and triton shells—while outside of them sits almost invariably a certain sea anemone (*Adamsia*), sometimes in great numbers, and the intervals are filled up with smaller species, so as to form a colony of the most diversified kinds. The inhabitants of the snail shells stand in a peculiar relationship to each other; for the crab pushes the sea anemone, with its long scissor-like claws, upon the house in which it intends to dwell. Whether it has any real need of its fellow-lodger we do not know. Mossy creatures (*Bryozoa*), polypi (*Sertularia*), lime and leathery polypi, colonies of different kinds cover the holes of this belt. Then comes the precipitous descent of the shore, where the treasures can only be observed at leisure from a boat. The descent is terraced like the shelves of a greenhouse, and is covered entirely with different kinds of coloured coral, or, better still, is actually constructed of coral rocks, upon which new generations are beginning to build.

"No pen or paint brush is capable of describing this splendour and beauty," writes Hakel, who examined the Red Sea fauna from the city of Tur. "No comparison made between these tracts of sea, teeming with variety of form and play of colour, and any lovely landscape bright with flowers, can give an adequate idea of their magnificence. For the blue depths are filled with flowers of every hue, and all these flowers are living corals. The surface of the larger coral reefs are more than two or three yards in diameter and are literally covered with beautiful star flowers. Blossom after blossom clothes the branching sprays and tendrils, and the large flower-cups at the base are also corals. Nay, even the bright, delicate mosses which fill up the interstices between the larger stems appear, when examined more closely, to be composed of millions of microscopic coral animalculæ. And all this floral splendour is lighted up into coloured flame by the burning Arabian sun, as it shines upon the crystal waters. In these wondrous coral gardens, which excel the fabled glories of the gardens of the Hesperides, swarms a world of animal life, embracing many and varied forms. Bright, metallic shining fish of the most curious forms and colours play round the coral petals, as the humming-birds of the tropics hover above the calyx of the flowers. Still more numerous than the fish are the different kinds of invertebrata which haunt the coral beds. Elegant, transparent shrimps of the garnel tribe dart swiftly by in large crowds, and bright-coloured crabs climb up along the coral branches. Besides these, red starfish, violet stars, and black sea-urchins climb in troops along the branches of the coral plants. The numbers of bright-coloured snails and shells are incalculable. Wonderful worms, with tufts of feathery gills, peep forth from their tubes. Then come swimming by a shoal of medusæ, and, to our amaze, we recognise in one beautiful bell-shaped creature a familiar medusa of our northern waters, the Baltic and the North Sea.

"Any one would suppose that in these enchanted coral groves, where every animal is transformed into a flower, we should find a reign of peace such as exists in the Elysian fields. But a nearer inspection of the busy doings of the flower-animals shews us that here, as in the life of man, the wild struggle for existence rages silently, but no less terribly and inexorably. The great majority of living forms which are unfolded in such unrestrained profusion are destined to die for the needs of a favoured majority. Terror and danger lurk on every side. To be thoroughly convinced of this, one has but to plunge down within the waters. With a sudden resolve we leap from the edge of the boat, and find ourselves bathed in green and purple light, and brought for the first time face to face with the wonders of the coral world. But we are soon taught that man is not allowed to wander with impunity among the corals, any more than beneath the palms. The sharp points of the rock coral forbid us to find a resting place for our bare feet; we look for a flat surface of sand, and the hidden urchin, diadema, pierces our feet with its long prickly spears armed with strong hooks; they break up into fragments within the wound, and have to be cut out carefully. We bend down to gather a beautiful emerald sea rose, which seems to be lying between the lips of a dead giant shell, when we find out just in time that our fancied flower is the living body of the shell, and that if we had unwarily seized it, our hand must have been miserably crushed between the two shells. We turn aside to break off a lovely spray of violet madrepore, but quickly draw back our hand on finding that a plucky little crab (*Trapezia*), which dwells in crowds among its branches, twitches us painfully with its tiny shears. Still worse do we fare on making an attempt to break off the flowers of the fire coral (*millepora*). Millions of microscopic poison bubbles empty themselves of their contents at the slightest contact, and the skin of our hand burns as if we had touched red-hot iron. Just as painful is the touch of a pretty little hydropolyp, which looks most harmless and innocent. At length, wearied out by this inhospitable reception, and not desirous of coming into contact with a swarm of burning medusæ, or falling a victim to the sharks, which are rather frequent visitors in these waters, we rise to the surface, and climb up again into our boat."

Among the corals, the great family of the madrepora coral is distinguished by the diversity of the species; but this coral, which looks like a blue-covered shrub, is not the true reef-building coral. The rock of the cliffs is principally built up by immense blue, brown, or black globes, clods, and columns of the coral *Porites*, meander, and star corals. The dreaded fire coral sometimes builds ledges in the rock, sometimes knobs in network slabs, or encrusts shells and worm tubes with every imaginable form. One of the most beautiful corals, especially remarkable for its peach-like colouring, is the cup star coral (*Pocillopora*). As the descent becomes steeper, the algæ are more rarely seen, but large tracts are found covered with the imperfectly calcined leather corals, or alcyoneæ, which the uninitiated is sure to mistake for plants. The black coral (*antipathe*) grows in great depths.

The Red Sea is very rich in fish. Thanks to the unwearied industry of Klunzinger, no less than 520 kinds are known. The fish of the coral beds, the so-called coral fishes, are as gaily coloured as their surroundings. As the parrot among birds, so the parrot fish (*Scarus*), with its bird-like mouth, claims the first place among the forms of unusual beauty. Rivalling it in attraction comes the great family of the lipped fishes (*labroides*), especially the coris and the rainbow fish (*Julis*), as well as the disc-shaped and very small-mouthed, scaly finned *Squamipennes*, especially the banner and coral fishes (*Chætodon setifer*, and *fasciatus*), the scourge-like fish, *Heniochus*, the prickly *Holocanthus*, the nasicornous fish (*Naseus*), and the hornfish (*Batistis*). Many kinds of bream (*sparoids*) love the dwelling offered by these slopes, and with their kindred forms, *Cæsio*, strike at once by their sky-blue colour. Several *Percoïdei* (perch, or berfish), and sea eels (*murœna*) are the pirate fish of this district. Among the inhabitants of the margin of the cliffs we find still more terrible forms, the grotesque jugulares, the dragon-fish (*scorpœne*), the red fire fish (*pterosis*), and most forbidding of all fishes, the *synanceia*. This creature sits motionless, hidden between weed and rock, and the pedestrian who passes by that way becomes first conscious of its presence, disguised as it is by a close similarity of its varied colours with those of its surroundings, by its suddenly starting up and inflicting upon him a very painful wound with its sharp stings.

Worthy of notice also are the globe fish, the urchins (*diodon*), the floating head (*orthagoriscus*), the casket fish (*ostracion*), the tobacco pipe (*fistularia*), the sea needles (*syngnathus*), and the sea horse (*hippocampus*), which, however, is rarely seen in this place. Ray are very seldom met with, but a small kind of shark is rather common.

The open sea, although far less richly peopled than the coast region, is still by no means poor in varieties of fish. Its denizens are all admirable swimmers, able to take any journey, and therefore possess a wide geographical distribution. Many of them are not only dispersed over the whole Indian Ocean, but also over the Atlantic as far as America, and in the Pacific. Some are even found in the Mediterranean and the North Sea. The greater number belong to the families of the mackerel and tunny, the horn and arrow-headed pike, sharks, and herrings.

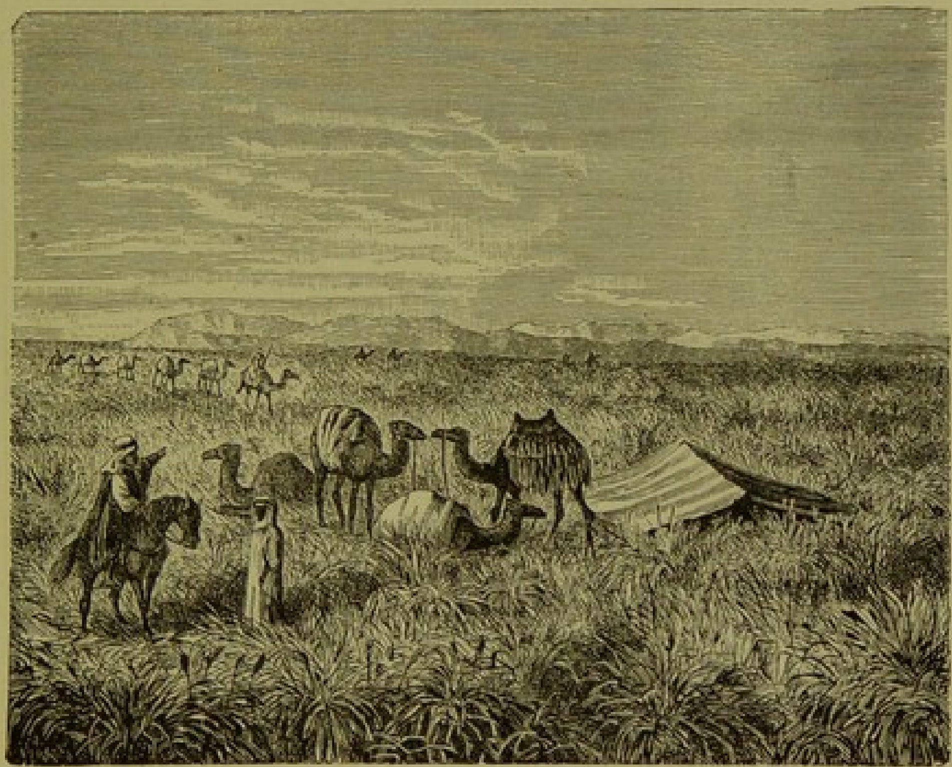
The ordinary methods of fishing among the fishermen of the town is the rod and line; the fish-eating Bedouins use the spear—the net is more rarely employed; and for larger fish, such as the dolphin, the harpoon is used. The fishermen do not like to catch the dolphin, because it moans so piteously in such a human voice. The curious sirene, or dugong, on the other hand, the *Halicore cetacea*, is a welcome prize; for its teeth are used as ivory, and sandal leather is manufactured from its skin. The best time for catching these cetaceous mammals is the nightfall, when they come up to the cliffs, and feed like cows upon the sea grasses. They are then easily caught in a large strong net, and their flesh is gladly eaten by Moslems, even though it may not have been killed according to law; "For," says the learned scribe, "every creature that comes out of the sea is a fish, and may be eaten without having been slain according to law;" and the same is true, of course, of the flesh of the dolphin and the turtle. Of the latter tribe the most common is the tortoise (*Chelonia imbricata*), which gives the precious shell. Pearl oysters are sought for less for the pearls which they contain than for the mother-of-pearl shells themselves. Black corals and rather bad sponges complete the list of treasures obtained from the sea.

Let us turn back westward, across the Nile, and wend our way toward the Desert of Sahara.

The mountain chains which bound the north side of the great desert, a barren tract ten times the size of Germany, must not be considered as solitary ranges rising from the plain, but as forming the terraces of the high table-land of Sahara, with its isolated mountains and mountain groups separated by numerous dry river valleys. We learn from the presence of numerous shells and petrifactions, some of which are still found in their kindred living forms in the waters of the adjoining seas, that the desert, notwithstanding its average height of from 390 to 400 yards above the level of the sea, was once submerged beneath the ocean. At the time of the great catastrophe which raised the bed of the sea and the high mountains rising from its surface, large tracts of level plain seem to have been raised with them unaltered. New masses of sand have been added to those which originally covered the bottom of the sea, some formed by the slow decomposition of rock and plain going forward through thousands of years, and some drifted up by the winds into sand hills and dikes, which appear either as solitary mounds, or long, far-reaching chains. Thus, by representing to ourselves this process, carried out systematically and on a large scale, we have throughout the whole of Western Africa, starting from the northern coast, a mountain chain extending more or less from west to east, from whose summits we scarcely have to descend upon the further side. To the south extend masses of dike-like hills of yellow sandy dust, followed by terraces of desolate plateaus and gravel-covered plains. The whole of the western part of North Africa corresponds regularly with this description, but the aspect of the landscape is somewhat altered on the road from Tripoli to Fezzan. The same causes which produced the two Syrtes, and broke the line of the northern coast of Africa, occasioned the break-up of the Atlantic mountain chain into tangled outrunners, and effected the formation of the numerous groups of oases of which Fezzan is composed, and which separate the western section of the desert from its smaller eastern part, the Libyan desert.

The statement that Sahara, with the exception of its oases, is wholly destitute of organic life, is so far supported by facts that we find a great part of the desert uninhabitable, from the absence of water, and only offering a sufficient quantity of food for a few animals; but it is quite untrue that there are boundless tracts where not even a blade of grass or anything but a miserably scanty vegetation can thrive at any time. It has certainly been stated that the construction of the soil is utterly unsuited for the development of plant life, that the roots cannot penetrate the bare, rocky ground, and that the sandy soil, so poor in earth, and liable to drift about at the mercy of every wind, either buries the plants, or is unable to nourish them. It is true also that these circumstances sometimes combine to banish all plant life from the Hammada or the sand-hills of the Areg; but the plateaus are everywhere furrowed through by fruitful valleys, or wadies, and relieved by numerous oases. In short, travellers only tell us occasionally that there is not a trace of vegetation to be seen, and by mentioning this as an unusual occurrence they prove that it is at least rare enough to call for special remark.

Of all the four formations found in the Sahara, the Hammada takes up the greatest space, and is also the most barren part of the waste. There are rocky spaces where the water cannot be reached in the depth, where the soil formed by decomposition cannot rest upon the ground because the wind carries it away, and the plants are too rare to supply a fruitful leaf mould. Sand or lime rock are the most prevalent forms. Timber trees are rarely found, and although there are scarcely wide stretches absolutely without a plant



ALFA GRASS.

growth, the vegetation is often limited to a few grasses, a kind of mugwort and a minute saltwort (*Caroxylon*). But when, as is very often the case in the Algerian Sahara, deposits of gypsum are found lying on the surface, or when in the neighbourhood of Mount Atlas the winter rains begin to be felt, a few thorny or leafless shrubs grow upon the Hammada.

In the Areg, or waste of drifting sand, also all signs of life are often wanting, especially on the dunes, of which we have given an illustration already, but where vegetation is as a rule more richly developed than upon the Hammada. Among the plants found upon it is the tall growth of the reed grasses, and we find altogether a vegetation not wholly destitute of use or beauty. To this district belongs the sparto or esparto grass (*Alfa, Halfa, Max macrochloa* or *Stipa tenacissima*), which covers large spaces of ground.

This grass teaches us more than any other form of the desert the inexhaustible qualities of nature, for every day brings with it fresh discoveries of the uses to which men can apply it. There is a certain grass called alfa by the Arabs of Algeria, which was once despised because it displayed such force and vital energy that it destroyed every other kind of plant, for it endures no foreign growth, and so became the terror of the colonists. But of late years it has been found so useful that far from destroying it, it is largely cultivated, and thus large tracts of land, once utterly worthless, are now won for purposes of culture. The first railway line among all those which are projected for Algeria is the "Alfa line," which is to run from Arzew to Saida in the province of Oran. To form an idea of the growing importance of this grass, the official report of its growth in Oran should be read; according to which, in the year 1863, about 20,000 cwt. of alfa was obtained, and in 1874 more than 1,000,000 cwt. Only the leaves are sent into the markets as esparto grass. They are narrow, from twenty to thirty inches long, and so tough that when they are gathered in the harvest they are wound round a staff, and then pulled off, so that they may not cut the hands. In former times the grass was used for the manufacture of mats, ropes, etc. The great spread of its importance is owing to its manifold uses in paper-making. The best alfa grass of

Oasis, with Date Palms.

commerce is the Spanish kind, doubtless because its good qualities are increased by cultivation; the Tunisian grass is as tough, but not so long, and the Oran grass is the worst of the three, because it is not so tough.

Most of the plants of Sahara are found united in the wadies. When the ground water rises in the winter, or whenever there is a shower of rain, their vegetation is developed with wonderful rapidity. It is stated by Duveyrier that when a shower of rain fell after a nine years' drought, a pasture land of rich green was seen in less than seven days in places which were previously free from every trace of organic activity. The rocky walls of the wadies enclose with their bare steeps the reviving fields where thornbushes and tamarisks were seen among a moderately tall grass, and where in isolated places some juicy herbage, sheltered by the thin foliage of isolated pistachio trees, attracted from time to time a troop of antelopes. The desert flora is principally composed of large bushes of spina Christi, whose fresh green offers a welcome rest for the dazzled eye: tall broom (*retama*), a creeping

LION AND LIONESS, TWO-HORNED RHINOCEROS, HYÆNAS, JACKALS AND VULTURES.

caper plant with large pink flowers and numerous tufts of grass, and the Nubian dwarf palm (*Hyphæne argun*), which finds its true home in the desert. Another striking instance of the conquest of life over the death-like solitudes is found in the colocynth plant, with its wide dispersion of seed, probably due to the agency of birds, and its succulent, quickly ripening fruit.

The oases, with their dark groves of the date palm, ought scarcely to be counted among the original vegetal formations of Sahara; since they owe their present state, their agricultural produce, their tree growth, and other cultivated plants, to artificial irrigation. They come originally from the wadies only; but how the few oases in which the date palm could grow wild were stocked before the district was cultivated by the hand of man is now impossible to shew.

The great causes which occasion these vast stretches of land to possess such a scanty vegetation are want of water and fluctuations of temperature. The drought of the Sahara is caused by atmospheric movements. The trade winds prevail unchecked within the desert; and as they come from the east, that is, over the dry lands of the Arabian plateaus, and then across Sahara itself, the air is never so dry in any other part of the earth as it is here. The scanty organic life of the desert is supported almost entirely by the subterranean waters; but the question as to whence these waters come is not easily answered without consideration. One example must suffice. The mountain streams of the Atlas, fed by the moisture of the Atlantic, pour themselves into the desert southward of Morocco, where they dry up in the valleys of the oases. But the disappearance of rivers in the desert does not depend, as is often said, wholly upon evaporation, but upon the actual sinking of the water through the sand. And as this influx of water is not received back into the atmosphere, or at least not until it has come to the surface as a well at a great distance from its source, the affluents from the mountains, scanty as they may be, yet form a constant supply which must be collected beneath the lowest depressions of the desert into large subterranean reservoirs. It is in this way that we are able to account for the frequent appearance of watercourses which are noticed in the desert valleys to the south of the Atlas, where in some places a mere moist strip of sand feeds the vegetation of the wady. Sometimes a well waters the plantations of the oasis; sometimes the ground waters lie so near the surface that the roots of the date palms which are planted in artificial trenches are able to reach it; then, again, draw wells are found, from which the water is with difficulty drawn to the surface; or lastly, a deep artesian shaft pierces the soil, and brings up the blessed gift for the solace of plants and men.

We must not forget the desolating effects of the desert wind. "We dug out some fresh water," Rohlf writes, "and set up our tents as quickly as we could in the shadow of some tall palm trees, for the last few hours had given us warning, by the blood-red colour of the sun, that the simoom wind was approaching. Scarcely had we finished before the hot dust wind began to blow with violence. In a moment the sun had disappeared from our sight, and we were all surrounded with a fine dust, which burnt our skin as it touched us. The fiery hurricane continued three days, with undiminished violence. The heat was certainly not very great, the maximum being only 91·4° Fahr., and the barometric reading was not particularly low; but, on the other hand, the atmospheric moisture was so diminished by the hot, scorching wind, that it might be said that the air was absolutely dry. In order to enable us to stand against this fiery atmosphere, we had to remain perfectly inactive, and to drink nearly ten quarts of water within the twenty-four hours; and for the first time I understood the possibility of dying of thirst in half a day during the simoom wind; for along the great caravan track the skeletons of camels are found in great numbers, and here and there the bones of unfortunate travellers who have succumbed to thirst or to fatigue. But the descriptions of older writers, detailing the burying of whole caravans under masses of sand, are probably most of them fictitious, or at least exaggerated."

It is clear that the animal life of Sahara is dependent upon the distribution of moisture in the desert, and it is the opinion of Von Russegger that in the larger and hotter deserts of the interior, far away from pools of water, there are no carnivora to be found, and that the fauna is made up of birds of prey, snakes, lizards, etc. The plants, like the flora of the steppes, are protected from the dryness of the climate by thorns or hairy coverings. Most of the leaf-bearing shrubs are consequently thorny, such as the *Spina Christi* and camel thorn, and a few plants of the nature of artichokes. The saltpetre plant (*nitraria*) combines the two formations of thorns and a succulent leafy network. The hairs, which temper the fierce rays of the sun, often shew great diversities of form, sometimes shading and veiling the outer skin like wool, as in the amaranthus, or clinging like a silken down, as in the mugworts; sometimes strong enough to prevent the loss of the inner juices, as in borage plants. We have already spoken of the rose of Jericho, and the edible manna, with their singular adaptations of form to the necessities of their existence.

But the plant life of Sahara is not only restricted by the want of water, but also by the great fluctuations of temperature, which are so considerable, both daily and yearly, that only specially organized plants are able to support them. In Algerian Sahara, for example, the heat of the day amounts often to 104° Fahr. in summer, while the thermometer falls by night to 71·5°, and in the winter the temperature often falls in one day from 68° to 21·2° Fahr.

The flora of the desert, if we except the cultivated plants of the oasis, is poor both in variety of species and number of individuals. The date palm is the only tree which is really a native of the desert; all others are importations, and only sparingly represented, like the acacias found along the banks of the Nile from Soudan, and the tamarisk (*Tamarix gallica*), which loves the salt soil of the shores of the Mediterranean. On the soil which is unmixed with salt we find chiefly leafless shrubs of the spartium type, which display a certain variety of growth and blossoming form, as *retama*, *calligonum*, and *ephedra;* while on the salt plains we find every variety of saltwort (*salsolæ* and *zygophyllæ*), which are common also in the steppes of Spain and Russia. A few grasses and lichens complete the list of vegetal forms which the traveller must expect to meet with in the Sahara; and it cannot be wondered at that the descriptions given of the oasis are found to be exaggerated, and that even the more unadorned reports appear too florid to us, who do not see anything very marvellous in shadow and water. But can one blame the traveller for this, when we remember that the oasis appears to him with all the force of contrast, and that perhaps a few moments before he was fearing death from exhaustion? "We came," said Rohlf, "to the true oasis of Jupiter Ammon. As soon as the heat made it possible, I left the place for the sand hills, and had soon climbed to the summit. But what a surprising scene met my gaze! At my feet the dikes, which only formed a small ridge, sloped steeply downward, and the fairest garden lay like a paradise of living green before me. There were no palm trees (which are not found here), but olives, of such wonderfully fresh green, that I took them for myrtles. Murmuring brooks wound through the gardens, not broad and rapid, it is true, but carrying blessing on their way, and full enough to keep all around them fresh and green, even through the hottest summer. 'The gardens of the blessed,' I thought; and I could perfectly understand the rapture of the warriors of Alexander, when, at the end of their terrible march through the desert, they came in sight of these delightful plains. In the north-west the gardens are lost in the pasture grounds (*Alhagi Maurorum*); in the east lay the lagoons, with a background of palms, numbering about 300,000; and the same scenery appears to the south-west. I descended quickly, and my first reward was found in the delicious balmy air and the cool shadows under the broad-leaved fig trees. Wending my way across the trenches, where the clear water was flowing freely, through rich fields of corn and clover, all lying in the shadow of thick-leaved figs, apricots, pomegranates, and olives, I found myself very soon in the neighbourhood of the ruins." Oranges and lemons grow only in Chamisa; but grapes, pomegranates, peaches, and plums are found in abundance everywhere, and there were some rather stunted specimens of apple trees. Whatever other trees have been mentioned by the ancients, such as the *elate*, a kind of date palm, and other resinous fragrant trees, they are not now found in the oasis and its vicinity, and probably, notwithstanding the statements of the worthy authors, never were found there, because the climatic circumstances of the desert do not admit of their growth. The fauna is meagre. Sheep and goats are introduced by the nomad tribes of Arabia. Donkeys are sent from Egypt; cattle are scarce, owing to the presence of a dangerous horsefly throughout the whole of the North African lowland, and in Central Africa. For the same reason the inhabitants can keep no camels, although the pasture grounds would supply them with abundant fodder. This fly, grey, and as large as a honey bee, plagues men and beasts alike, its sting drawing blood at once, but raising no swelling. There are a great number of wood pigeons sporting and tumbling among the olives; and as the trees are found growing close to the spring, where the doves find both shade and shelter, the natives have given it the name of the doves' spring. Such is the once famous oasis, whose sanctuaries now lie waste in unheeded ruins. Who, upon seeing them, would not remember Rückert's lines:—

> "And when five hundred years have fled,
> Again this selfsame path I'll tread"?

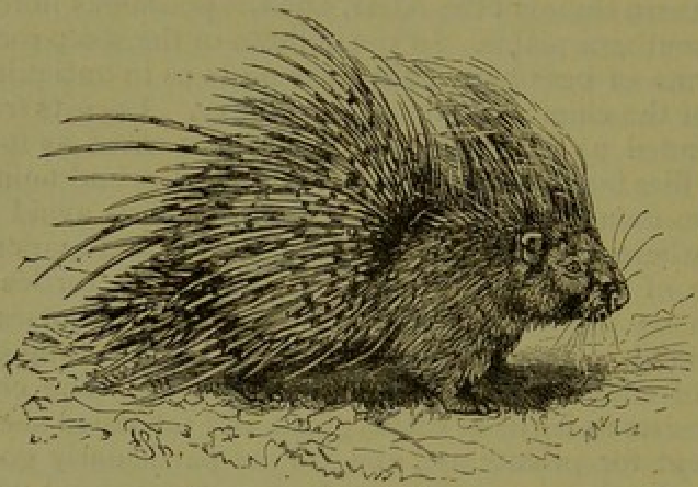
Memories of the past are still more keenly recalled at Cyrene, that part of the table-land of Barca where the scattered ruins of the Pentapolis remind us of the vanished glories of Grecian culture; where the land is still a garden, but where there are no men to sow, or even to gather the fruits. The ancients used to distinguish between many vegetal regions in Cyrenia, and to say that many harvests could be reaped, first on the plains, then along the slopes, and lastly, from the table-land itself. Such is the case at the present day. And when we read Homer's praises of the fertility of the pleasant land, or Pindar's words about Cyrene the fruit-yielding, the garden of Jupiter and Venus; or the pages of Diodorus, who calls Cyrene's simply the most fertile soil; or of Arrian, who describes it as full of plants and well watered; or the long list of Cyrenian fruits given by Stylax, we find nothing exaggerated, and are able to re-echo their praises, so rich and luxuriant is the flora of to-day. Indeed, when we have left the town of Bengasi behind us, and, following the coast, turn our steps toward the interior, we fancy ourselves wandering in a beautiful garden. We pass through meadows bright with flowers, where the distant view is bounded by myrtles and lentiscus; and on ascending the mountain we are met by rosemary and juniper, and by large bushes of white roses which carry our thoughts homeward, while in the moist ravines red oleanders and laurels represent the plants of southern Europe. And this is the characteristic vegetation of the district. Among the large trees which are chiefly found on the high table-lands, and in the valleys running toward the north, are the small-leaved evergreen oak; the cypress, often 130 feet high; the thuja, and the juniper. Among the shrubs are laurestinus and arbutus. Olive, fig, carob, and pear trees are found growing wild; but the vine is not seen, although in ancient times wine and oil were the principal exports to Sicily and Greece. And as in those long past days the grotto of Circe was incensed with fragrant thyon, so in our own times a fire of juniper wood sends out pleasant odours; and the burial caves, in which travellers sit and rest, kindling a fire of juniper wood to warm and light them, seem as if they were perfumed. This probably is the wood used by the ancients for the manufacture of the celebrated scented furniture, of which the thyades, or drinking tables, were particularly admired. Some writers, however, believe the *Cedrus Atlantica*, or Atlas cedar, was the costly thyon of classical times. Cyrenia was also famed in its golden days for its rose-water and other fragrant vegetable products. Even now we have but to stretch out our hand to find sweet-smelling plants on every side; geraniums, mugworts, and violets fill the air with their odours. Edible plants are found growing wild, and are of excellent quality, especially artichokes, and, best of all, Pliny's famous truffle, *Misy*. The perfumed fruit, spagnus, so much praised by the ancients, is not known now; but the chief wealth of the neighbourhood was the sylphium. The juice of the plant, prepared with bran, was celebrated as a specific, and sent throughout the civilized world under the name of *Cyrenaica*, tears. The Romans considered sylphium as precious as gold, and kept it in the treasury of the state. In later days, when the place became a Roman province, the plants became so scarce that a solitary plant was offered as a valuable present to Nero. The reason of its disappearance was explained by the ancients in various ways. Solinus says that it was destroyed by the inhabitants in order to evade the tax set upon it; Strabo charges the invading barbarous tribes with its destruction. It is very likely that both causes united in producing the result; for the Libyans, coming with their camels from the desert, would naturally try to do away with a plant which was fatal to their animals. Sylphium had a most injurious effect upon cattle. Both goats and sheep were very fond of it; but after eating it, Arrian tells us that the goats began to sneeze and the sheep to sleep, so that they were penned in to keep them from it. The same peculiarities are found in a plant which to-day is called by the inhabitants drias (its botanical name is *Thapsia garganica*), and has often been taken for the sylphium of the ancients, as it is also similar to the latter as stamped upon coins which have been preserved. Others think the asafœtida to be the sylphium of the ancients. However that may be, the question still remains, why is the thapsia of Cyrene different from that of any other place? And yet there must be a difference. No peasant of Algeria or Morocco ever thinks of muzzling his camels, as is done in Cyrene, as soon as the path lies through places where the *Thapsia gyranica* is found, nor does he attribute any particular medicinal qualities to the plant; while in Barca the inhabitants still look upon the drias as a specific. The vegetable world of Cyrenia is relatively very rich; but it is true here, as it is in Tripoli, that a better cultivation of the soil would enable the country to rival any part of the northern coast of Africa. For instance, the so-called Maltese orange and the fine mandarin oranges of Tripoli have now found their way into the European markets, and the grapes and figs are also very good; while all vegetables cultivated in Europe thrive so freely in Barca, that if the means of transport were a little less irregular, the winter markets might be as well supplied with vegetables from Barca as they are now from Algeria.

The deathlike aspect of the towns of Cyrene almost inclines one to fancy that they exert a hostile influence on living animals. Along the coast exist many wild, that is, undomesticated animals, hares, rabbits, gazelles, and all the quadrupeds which are generally found along the northern coast of Africa; bats, porcupines, and several kinds of rats are also common, but fewer in number than in Tunis, Algeria, and among the rich fauna of Morocco. No carnivora, except the hyena and the jackal, are seen; even the fox, wild cat, and lynx, so common in Tripoli, are wanting. Wild boars inhabit the ravines of the high table-land, but in small numbers only. Molehills lie in the path on every side, and their traces are seen far across the plain in a southerly direction. The bird world is poor, and has no characteristic varieties, and yet the neighbouring kingdom of Tripoli has eagles, falcons, owls, ravens, goldfinches, sparrows, nightingales, canaries, wagtails, swallows, doves of various kinds, partridges, quails, snipe, ducks, geese, flamingoes, and especially ostriches. Lizards, snakes, scorpions, spiders, and other kindred insects and reptiles are the same as those of the northern slopes of the Atlas, and the poisonous horned viper is often seen upon the southern plains. In the hollows of the steep rocky walls of the highlands, swarms of bees have built their nests as in antiquity; so to this day honey is one of the chief exports of the country. Locusts from the south are sometimes dreaded as a plague, and sometimes eaten as food. Crickets, stinging gnats, and flies innumerable abound. Horseflies and animal and human parasites are also found. It is a singular fact that fleas avoid all those portions of the desert where no rain falls. In the springs and marshes, here as well as in the oases of the desert, leeches are found, and turtles of various kinds are often seen on the water-side. The once famous horses of Cyrenia have sadly degenerated in symmetry and beauty, though they still possess the good qualities of endurance, docility, and strength. The chief wealth of the inhabitants consists in herds of cattle, goats, and fat-tailed sheep. Asses and mules are only kept for private use, and are not particularly good. The southern plains, on the other hand, are famous for the camels bred upon them, the Cyrenian camels being highly prized in Egypt.

Our way onward lies through Tunis, along the northern coast of Africa, and leads us to the far-famed Algiers. A magnificent landscape opens out eastward and westward. Numberless pleasant villas, with their white cupolas, rise shining from the green of the orange, laurel, pomegranate, opuntia, and agave trees; the ramparts, the imperial fort, and the lovely Moorish gardens, with their clusters of pomegranate and orange trees, with here and there a cactus or date palm, produce a striking effect. "And yet whoever knows Algeria," says Wachenhusen, "knows that, besides the few fruit gardens, that of Tlemcen in Oran, of Metidscha in Algiers, and the oases of Constantine, everything is barren desert, and even the Metidscha was artificially transformed into a fruit garden. The traveller can journey for miles together through the country without seeing a tree or a shrub. High overhead, perhaps, upon the barren plateau, rises a lonely, stunted, and withered tree stem which has long since lost all its verdure; a raven sits upon its rotten branch, a snake suns itself at the root, and, shunning all companionship, the black and white scorpion creeps philosophically under its stone. And this is all the life which the traveller meets with, unless he chooses to consider as such the nightly howl of the jackal and other chance cries of nocturnal animals.

One of the most characteristic forms of plant life along the coasts of Algeria is the dwarf palm (*Chamærops humilis*). Its short trunk is generally imbedded in the ground, that is, buried under drift-sand; and the more freely it grows, the more seldom it is seen of any considerable height; but in better soil, or in places where upon its rock it "pines all lonely," and is prevented from putting forth shoots, it attains the respectable height of from twenty-five to thirty feet. These fan palms are never seen far from the coast of the Mediterranean, they are seldom seen on moderate elevations, and generally avoid mountainous tracts; but here they grow on the hills, and even on the higher mountains. The coasts of the Mediterranean are covered with impenetrable shrub and bush extending for miles. Another plant, less striking, but none the less worthy of our notice, is the litmus or orseille lichen (*Roccella tinctoria*), which is found upon the rocks near the African shores of the Mediterranean.

Among the plants cultivated in our own day are cotton, alfa grass, cork oak, and the gum tree (*Eucalyptus globulus*). The finest quality of cotton is obtained from the soil of the bed of the great Hallula lake, which is drained for a distance of more than thirty-two square miles; and the large plantations of the gum tree, which is a native of Australia, have saved the land from many a fever. In many places the forest wealth of the country is inexhaustible, and yet, before the taking of Algeria by the French, the woods were in a very wretched state, because the Khabyles used to burn the grass in great tracts yearly. The forests contain coniferæ, oaks, elms, chestnuts, ash, beech, poplars, willows, pistachio, wild olive, and carob trees. Among the oaks the most important is the cork oak (*Quercus suber*), from the trunk of which a layer of cork can be stripped every seven to twelve years (the time varies according to the district), and is then sent into the markets as the cork of commerce. The silkworm rearing yields about 300 cwt. of cocoons. Lions, once frequently found, are now scarce. The treasures of the Mediterranean, including the coral found upon its African shores, will call for our notice later on.



PORCUPINE. Length, 26 inches.

But little is known of the natural history of Morocco. Rohlf, who is undoubtedly the best authority on the subject, gives us the following description of a journey across the great Atlas. Writing from the neighbourhood of Asro, he says, "I have not the power of depicting the grandeur of the scenery of this district. The larch was the most common tree, and it reached to dimensions such as I had never seen it attain elsewhere; trunks of nine to twelve feet in circumference I found to be no rarity. Everywhere virgin forests with noble oaks, and our medlar, which also grows to a great height. Large trunks of dead trees, which are left lying untouched, barred our path from time to time. Round our path and beside us bloomed rhododendrons, buttercups, and lilies of the valley; so that we could fancy ourselves in Germany or Switzerland, instead of upon one of the highest summits of the Atlas. After about two hours' march we crossed the first ridge of the chain, and found ourselves looking down upon the beautiful inland lake Sidy-ali-Mohammed, a sheet of water about a mile and a half in width and nine in length. Surrounded on every side by well-wooded forests, and adorned with a small island near its southern shore, the water alive with flocks of ducks, the lake forms a fine panorama. Soon afterwards we encamped on the southern slope of the mountain, in the midst of the wood. The larch, which had so far been the principal tree, was now no longer seen, and the forest was composed of the tree of life (*Thuja orientalis*), the oak, and the juniper. At this point we found the cattle secured within strong enclosures, to guard them from the attacks of lions, which are said to abound here. I neither heard nor saw one, but it is quite possible that they are found in the forests, since the latter contain all the food and shelter they seek."

"The whole district of Fezzan," says Nachtigall, "belongs to the desert, and even the most northern of the oases, scarcely sixty miles from the Great Syrtes, are surrounded by barren wastes. The situation is well fitted for the scanty animal and plant life so far as it is independent of human aid; while the large pasture grounds of Tripoli attract numbers of nomadic tribes in the right season, various kinds of thyme and mugwort and *Peganum harmala* covering the heights. *Pistachio atlantica*, tamarisks, broom, retaman, and sumach (*rhus dioica*) are common. In Fezzan the wild flora ceases altogether. Once again, during a short period of the year, nature breaks forth into an ephemeral vegetation upon the slopes of the black mountain, but the eye soon loses all trace of vegetation upon the bare rocky soil, and only in the sandy levels of the ground does an acacia, called *Talha*, unfold its modest foliage, and tamarisks and a few herbs eaten by the camels, such as the prickly leguminous *Alhager maurorum*, a few stiff soda plants, senna (*Cassia aborata*), and colocynth, relieve the desert solitude. The fauna is still more scanty, and is almost entirely limited to the oases. Only upon the mountain slopes surrounding Fezzan, and in the valleys between the hills, the maned sheep, the gazelle, the jackal, the desert fox, or fenec, and the mouse tribe lead a precarious existence. The ostrich, which, according to many reports, must have been at one time a frequent inhabitant of the northern parts of the Sahara, has now retreated southward, and the bird world is only represented by a few birds of prey, sand-grouse, doves, ravens, and owls. Certain of the reptile tribe are comparatively more numerous, sand gekkoes, waran lizards, vipers, and, commonest of all, scorpions; while some insects, as for instance fleas, are unknown, and others, as flies and gnats, find a limited development in time and space."

When the burning sun sinks toward the earth, and the living creatures breathe in new life with the cool evening air, another set of beings, more or less sinister, but just as sleek and alert, begin their daily, or rather their nightly, work. I will not speak here of savage hyenas or howling jackals, nor of the desert lynx, the caracal (*Felis caracal*). It is a faint, indescribable shriek that arouses our attention, and we see, if we are fortunate, creeping along between the sand hills or the rocky clefts, or in the wadies, the fennec (*Canis cerdo*) watchful, spying, listening, scenting the air on every side. Nothing can escape the sharp vision of this thorough-paced pirate. The locust yonder, taking his last evening leap, has made just noise enough to catch the ears of the fennec, and more in curiosity than greedy hunger, the animal steals up to find the author of the noise, and puts an end to its existence. Or the nimble lizard has moved, and in a moment the fennec is at hand to see what is going on. Its chief food is birds, and woe betide the field lark which happens to be sitting near the path along which the fennec wanders! It is lost if it does but stir a wing—a child of death if, thinking dreamily of its simple song, it allows one note to escape. And threefold woe to the sand-grouse (*Pterocles*), for the fennec hunts it down as its favourite prey. It has no need to bring down much game ; a single grouse provides him with a meal sufficient for himself, and perhaps also for his hungry family.

Domestic animals are but poorly represented. Cattle are the scarcest, and the horse is not much more abundant ; both are importations from the north, and are only possessed by the richer or nomadic tribes. Sheep either come from the north—they are then of the fat-tailed breed, with thick woolly fleece—or they are natives of the south, from Tuarik or the Tuber lands, and are distinguished from the former by a larger frame, a long thin tail, a narrow head, and long, slightly waved, fine hair, instead of wool. Goats are smooth-skinned and short-haired, and not much more numerous than sheep. Dogs are scarce, and either long-haired white watch dogs, or rather pretty medium-sized greyhounds for the chase. The only domestic animals are camels, fowls, and pigeons, which are bred by the people of Fezzan, and need no supply from abroad to keep up the breed. From the comparative scarcity and the high price of sheep and goat flesh, fowls and pigeons are often killed to supply its place, and the poorer folk seek their food from the inhabitants of a little lake, Bahr-ed-Dud, or Lake of Worms. The lake contains an immense number of crustacea peculiar to the brackish water, a crustaceous animal, the *Artemia oudneyi*, about one-third of an inch long, and is also rich in numerous larvæ of insects. These edible water creatures, of which many kinds are found, are eaten with danga, a sort of weed found in the same lake ; and, kneaded into a paste with the addition of various spices, are much approved of by the natives. The fewer resources able to be obtained by the people of Fezzan from cattle-rearing, the greater efforts they make to wrest some assured means of livelihood from the soil on which they live. The latter, ungrateful as it is for the culture of any kind of wheat, and great as is the labour it demands for fruit or vegetable growing, yet, from the water it contains, is suitable for the growth of a tree without which it would hardly be possible to imagine the existence of the people of Fezzan, or indeed of any of the north African lands. This tree is the date palm, called by the Arabians, *Nachla*.

Few people have any adequate idea of the abundance of valuable qualities and the inexhaustible resources which this wonderful tree brings to the child of the desert in his poverty-stricken home. It is the hope and joy of the traveller who for days together has dragged his weary limbs through the solitudes of the rocky waste, over the weary chain of sand-hills, and at last on the horizon sees the green line of the Rhaba, or plantation. Eagerly his gaze rests upon the colours of hope and life, the thin line broadens more and more, gradually unfolding its separate details, which he follows with a joy beyond description. Soon he is able to distinguish the graceful crowns, which, from the summit of their tall, slender stems, seem to wave as if in friendly welcome. His eyes wander searchingly from group to group, as they reveal more and more of their enchanting beauty ; he strives to choose a camping ground from which he shall lose none of their loveliness and shadow. What is the oasis without the date palm ? An uninhabitable pasture ground with a scanty vegetation, which, were it not for the refreshing shadow of the sheltering palm, would soon come to the end of its short-lived existence. In Fezzan the value and worth of the palm is fully appreciated ; it is the consolation of the poor, the helper and succourer of all. It appears to reach the underground waters throughout Fezzan, and needs no artificial irrigation ; it is the only gift yielded by the inhospitable land to the needs of its inhabitants, but it is a gift bestowed with royal generosity. Even if corn is sometimes considered as the most solid basis of food, yet there are many people who think more of the fruit of the palm, and most award it an equal rank in importance. And every part of the tree is of priceless value. The stem is simply called *Chescheba*, or " wood (timber) for use," and indeed it is the only wood for building or any other purpose. The leaves are used for the erection of huts, and as fences round the gardens; their strong ribs are used for canes, sandals and baskets are woven of their leaflets, the thick end of the leaves is used for fuel. Durable and good rope is made from the fibre of the bark, by soaking it in the moist earth, and then rubbing and pulling it out by hand ; and the summit of the stem, which is itself edible in its wealth of sugar and sap, yields a favourite saccharine beverage, and, when fermented, a strong, heady wine. The fruit is eaten in its fresh, soft condition; but as most of the dates are required for storing, they are generally gathered before they are ripe, and spread out in the sun, which ripens and dries them at one and the same time. Good trees yield a yearly harvest of 4 cwt.; but, on the other hand, a hungry man requires 10 lbs. of dates a day, and we must remember that not only men, but goats and sheep eat them with much relish; even dogs like them, and they are occasionally used to supply a deficiency of fodder or barley for horses and camels.

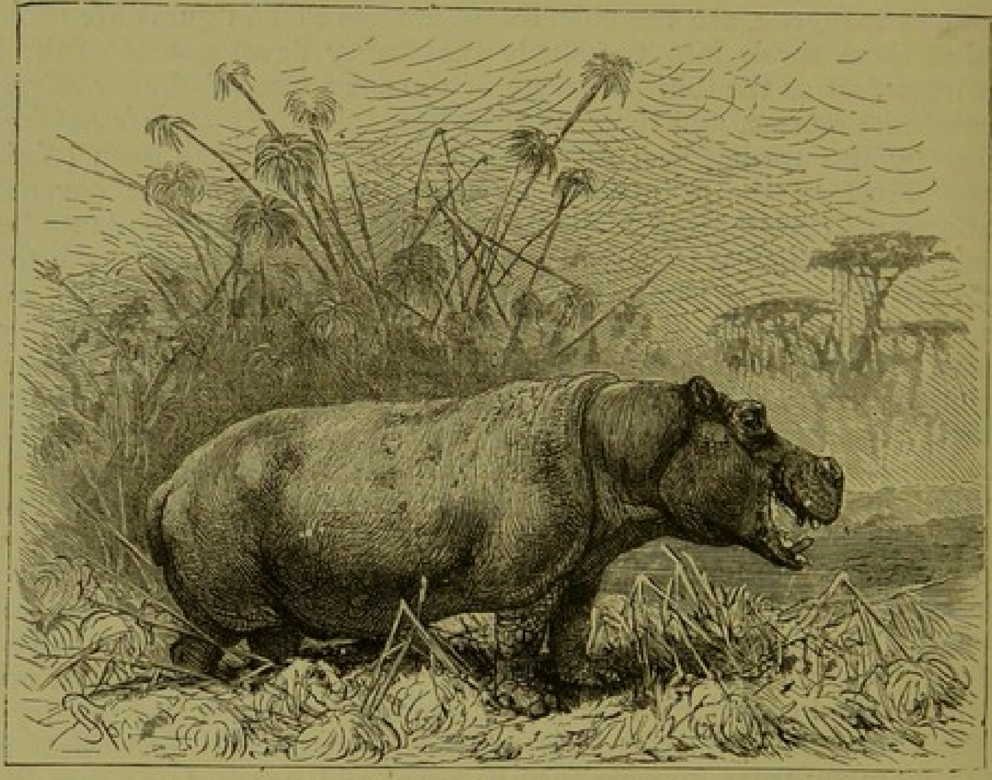
Corn plays an equal part with the date in the welfare of the country, but the soil, which is all lime and sand, with a little clay here and there, needs to be regularly watered, and as manure is not to be had, it is greatly exhausted, and drained of its resources.

In Mourzook we find the northern cereals, wheat and barley, together with the tropical ones, maize, durra (a kind of millet), and penicillaria; the former ripen in winter, and the latter in summer, yielding as many as four crops. Among the vegetables cultivated are beans, peas, carrots, turnips, radishes, gourds, melons, water melons, tomatoes, onions, garlic, Spanish pepper, mallows, coriander, beetroot, cole rape or cabbage turnip, celery, caraway seed. Fruit trees are of course out of the question, always excepting the date; but attempts are made in the gardens of the richer inhabitants to acclimatize the almond, peach, apricot, and pomegranate tree. Of all the useful plants which are not cultivated, colocynth takes the first rank, the kernels yielding, by dint of much labour, a considerable addition to the food of the poorer classes. To this must be added the fruit of the doom palm and the truffles (*terfezia leonis*). Luzern and clover are important plants, and are found in every garden. Equally indispensable is the stimulating herb tobacco, which belongs to the common order of tobaccos, and is used for chewing, while the tobacco used for smoking is imported from the north coast. Flax is cultivated for oil and medicinal purposes, and henna (*Lawsonia inermis*) for medicinal uses and for cosmetic. Much trouble is expended upon garden culture. No dependence is to be placed upon rain, which falls very seldom; for instance, in the winter of 1868-9 it only rained four times, and then the rainfall was but slight; and the water, which is found everywhere at the depth of five to six yards below the surface, is distributed by draw-wells worked by asses. For this purpose the garden is divided into little dammed up squares, between which are narrow channels, and by the alternate opening and shutting of the dams each square is placed in turn under water for at least one whole day during the week.

We must not leave the desert without saying a word as to the influence of the temperature upon human beings. Nowhere does the cosmical influence upon the mental and physical life of man make itself so distinctly felt as under the burning rays of the tropical sun; for man does not only live upon the earth, but by it, depending upon it in every sense with his whole being; and like the face of nature, on which the child of the tropics looks, so do its tints and humours mirror themselves in his soul. But these reflections are manifold, and vary according to the vesture worn by the earth, whether it lies bare and poor in vegetable life beneath the scorching rays of the sun, or whether the rich robe of luxuriant flower-brocaded tapestry is woven round its frame. Wherever the eye meets this fulness of beauty, man goes out of himself into the rich life around him; but when his gaze wanders through vacancy, it returns back into himself; in the one case the soul is governed by the senses, in the other it is absorbed in its own thoughts, visions, and reveries. And thus the desert is the land of fanaticism and of slavery; the forcing bed of the marvellous wonders of the Thousand and One Nights, of fancies robed in oriental splendour, of parables and fairy tales, of brilliantly woven word tapestries glittering with the blinding sparkle of sunlight and starlight, of gold and precious stones; and yet it is also the charmed circle of self-annihilation, of the death-like torpor of ascetic contemplation, the focus of dreaming souls, prophetic visions and deliriums, prophesying and revelations, the cradle of culture and religion. But further, the dense luxuriance of the primeval forest is the land of non-historic existence, the cradle of the life of the moment, of coarse incoherent superstitions, the home of the poison-tipped arrow, the shelter of unrestrained natural impulses, and a dull religious sense. When, for instance, the Bedouin encamps by the side of his swift graceful mares, near the cool gurgling spring under the shadowy date palm, above him the deep gold of the stars in the purple sky, or the never-clouded orb of the burning sun, and round him on every side the trackless desert sand, the nomad tent, with his wives, children, and kinsfolk, the wandering home where he was born, where he has grown grey, where he will one day lie down and compose himself for his last sleep—then what wonder if there arise before him, woven of light and vapour, of glaze and glow caught from the vague, silent, lifeless spaces, the grey silver-haired Saga draped in gorgeous light and colour, and speak to him, as in the past she filled the brains of his fathers and forefathers with dream pictures, haunting the boundless space around him, where, besides himself, the faces and voices of his fellows are the only sights and sounds to be seen or heard? No overpowering wealth of form, no thousandfold voice or vision of the outer world disturbs his forgetful, contemplative trance, his losing himself in the great All, his thoughts and visions. But there, in the rank forest, where the panther steals, plotting murder, through the never-falling foliage of the woods, where the glowing heaven pours down upon its earth-bride every charm of colour, undying youth, and manifold organisms of life; where strength, fulness, and vitality are combined in unstinted measure, and yet never hinder each other's development; where fresh life and movement bewilder the eye, distracting the thoughts, and dissolving the soul in ever-changing impulses of sense; where, in short, the thoughts are fascinated and spell-bound by the attraction of the moment—there is no space for vague reveries, deep contemplation, the research of historical antiquity, or musing leisure; but silent, like the panther or the poisonous snake of his native land, the savage, armed with his poisoned arrow, steals through the forest to bring down his prey or to slay his foe.

Central Africa.

"The rocky desert, in its typical form, had already been left far behind us," says Nachtigal, when, on his toilsome journey through the Sahara, he approached Tsade. "The weary region of the sand-hills," he writes, "lay behind us. A high, broad, undulating stretch of sand had taken its place, and began, especially in the depressions of the soil, to be covered with vegetation, which soon widened into an unbroken carpet of plants. The plants and animals restricted in other parts of the desert to the oases or the river valleys are found here distributed over the whole scene. The sky, hitherto so cloudless, begins to be flecked with clouds; and the dry skin, which remained parched even amid our greatest exertions, now was moist with perspiration. Near to the oasis of Agadem, the eye, wherever it turned, saw herds of the Mendes antelope (*Antilope addax*) quietly grazing and shewing no signs of fear at our approach, as they are very seldom exposed to any pursuit on the part of the ıhabitants. At length the rich herbage of the plain changed into the dense :eppe landscape, the Tintumma." The latter is a wide, boundless plain, more r less undulating, in some places richly covered with grass, in others more paringly, but never wholly free from vegetation. The utter absence of any se in the ground, which can be seen from any great distance, the lack of any odden paths, the utterly monotonous character of the Tintumma, make it npossible to traverse it without a guide, and justify its name, meaning, "thou ilt see thy mother no more" (if thou leave the caravan). At length the canty groves of trees are replaced by a continuous, but open wood; then omes the great mimosa forest, which appears to traverse the African conti-ent, from the west coast to the Red Sea, like a belt, which is in many places four or five days' journey in width. It stretches out in open park scenery, with rassy glades and clearings between the bushes and the groves of trees. The horny, fruit-bearing zizyphus, and the thornless serrah tree (*Maerna regida*), tree like the myrtle, are the chief forms, acacias rich in gums are often seen, nd all of them throw into the shade the scanty development of the former lesert trees, just as the dull colouring of the soap tree (*Balanites Ægyptiaca*), he desert-like retama, and the almost leafless tundub (*Capparis soddada*), are xcelled by the fresh green of the thickly foliated sivak bush (*Salvadora persica*). Most of the trees, and especially the acacias, are covered with parasitic plants (*loranthus globifer*), and embraced by climbing plants (*momor-dica balsamina*), which send down their aerial roots towards the earth from the branches overhead. The true camel-grasses of the desert, Agâl, Aqûl, and Had (*Alhagi maurorum, Cornulaca monacantha*) have disappeared, and the prickly akresch (*Cenchrus?*), and other grasses prevail. Treacherous seed capsules lie upon the ground; the three-sided, sharp-pointed Kâje (*tribulus*), and the flat prickly dreze (*neurada*), which pierces the traveller's foot, while his clothes brush the dreaded prickly grasses (*Pennisetum dichotomum* and *Cenchrus echinatus*), whose myriad prickles cleave to his clothes and his skin. But there are other and less hurtful grasses ready to rejoice the eye by their beauty of colour and variety of form. With intense pleasure the gaze of the traveller in the desert is arrested by these creations of nature, whose charm is increased a thousandfold by the contrast of the dead, barren waste which lies behind him, though tropical wealth is not yet reached. At the time of drought even the northerner would consider all trace of luxuriance vanished, and the dry season lasts more than three times as long as the rainy season. The whole steppe, spite of its many trees, appears then as burnt and parched; so that Barth, in describing the Tintumma, speaks of it as a widespread, lifeless, terrible waste, and Vogel writes of the Tintumma desert, "It is only where well-watered river valleys or standing waters supply the necessary amount of moisture as perennial streams, that the character of freshness is preserved throughout the year. Here, not far from the well of Belgaschifari, we came upon the first traces of the lion, who needs water and shadow, and finds plentiful opportu-nities for hunting the antelope, and following the large footprints of the slender and shy giraffe, which finds here the wide spaces where men are so scarce and vegetation so abundant. Along the slopes grazed the charming mohor ante-lope (*Antilope mohor*), also called by the Arabs 'Ariel,' white, with broad brown collar stretching across the neck; and, not far from the antelope, the ostrich, which is said to cherish a special preference for its society. Meanwhile the forest round about re-echoed with the long-missed voices of the birds. Now the ground was covered with curly, whity-brown, or striped black and white centipedes (*scolopendria*). The ground was also strewn with countless little spiders, of splendid purple colour and velvety bodies. The popular belief concerning these spiders is that they produce the red velvet brought from the Christian lands, because the only thing they have seen at all like them is the red velvet which is brought from the north coast of Borneo. As we drew nearer to the Tsade, we came on the track of elephants, doom and date palms appeared, rich pasture lands interrupted the thick tree-growth, the forest resounded again with the voice of birds, but we looked in vain for any trace of human life and activity. Full of expectation, our glances sought to penetrate the forest, and to discover the celebrated Tsade lake or the first negro village. We were soon treading the sandy chain of hills which bounds the lake towards the forest. A grassy plain of about a mile and a half in width separated us from the shores of the Tsade, and along the banks extended the long succession of the sugar-loaved straw huts of Ngigmi. Flat and unadorned, with monotonous



River Horse, or Horse of the Nile (*Hippopotamus amphibius*).

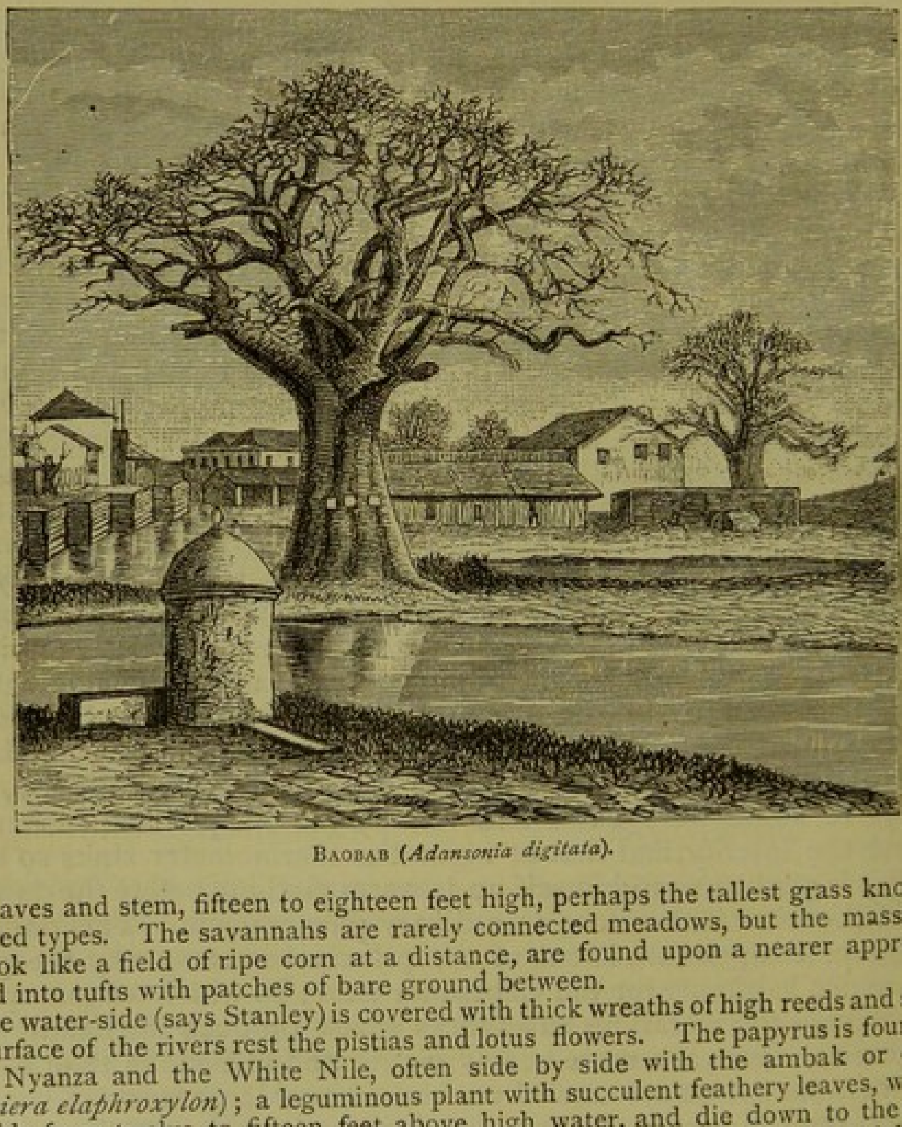
shores and sedgy margin, lay the famous lake before our eyes. Long years ago, in the tedious school hours, I had dreamily gazed upon its outline, which then, with the fabulous mountains of the moon, formed the only adornment of the map of Central Africa. Now I had reached this goal of my childish dreams and of my later life; but the reality did not fulfil the expectation of my childish dreams. If, however, the vague shore, with its tangle of sedges stretching far into the centre of the lagoon, and the shallow tongue of land crossing the water in the distance, had something unspeakably flat and monotonous—and its aspect from its boundless horizon had something in common with that of the desert—we felt fully recompensed by the strange, diversified life unfolded before us along the shore. The large meadows surrounding the open district are covered with oxen, asses, sheep, and goats; the natives move quickly to and fro; countless aquatic birds, foreign-looking storks, herons, ducks, pelicans, and dark-coloured geese, sought for their food unmolested by man or beast;

and near the village a peaceful elephant stands at the edge of the water, slaking his thirst and splashing the water over his great body. I made use of leisure time to hasten inquisitively to the shore of the lake from which the harmless elephant had retreated. From twenty to thirty other pachydermata, hippopotami, tumbled joyously in the water. Curious, ignorant of the murderous propensities of civilised men, they came fearlessly to the water's edge, and I took care not to disturb their play. Any metallic noise seemed to strike them with great pleasure, and, even when all of them had apparently withdrawn, one might be sure that the beating of a copper kettle would attract the music-loving creatures from every side. The strange-looking monsters did not come to land till after nightfall, and I was never weary, as long as the darkness permitted, of watching these vestiges of a former creation, with their long, low bodies and heavy heads, how they went routing about the ground for their food like prehistoric pigs, and when disturbed betook themselves to the water, scurrying along on their short legs with incredible rapidity. The inhabitants of Ngigmi offered us fowls, onions, dried fish, milk, butter, earth-nuts (*arachis hypogæa*), bad water-melons, tobacco, cotton seed, Soudan pepper (*capsicum conicum*, var. *orientale*), millet (*argum moro*), indigo, etc. A fowl could be bought for half a dozen glass beads or three or four knitting needles from Nürnberg."

The vegetal district of Soudan, in which we are now, rejoices in tropical rainy seasons, corresponding to the altitude of the sun, and is exposed at intervals to the mastery of the dry trade-winds. Near the equator, the two days of the sun's zenith (about the 21st of March and the 23rd of September) are separated by half a year's interval; and then gradually draw nearer together until they coincide at the solstice. The higher tropical latitudes have therefore only one, and that a comparatively short, rainy season, lasting from three to four months, while near the equator there are two rainy seasons, whose united duration generally amounts to six or eight months. There are, however, several exceptions to this almost universal rule, especially in the mountains and along the coasts; for instance, in the highlands near Lake Victoria Nyanza, rain falls in every month. The size and relative uniformity of the Soudan exerts also considerable influence upon the fluctuations of the temperature; and Central Africa is distinguished from India and South America by the great chilliness of the nights in comparison to the heat of the day. Livingstone, when travelling in the neighbourhood of Njassa, noticed that blocks of stone were burst and rent by the unequal expansion of the surface and the interior, and that at night the thermometer sinks so low that the traveller is glad to wrap himself up in warm clothing before the dawn. An abundant fall of dew is therefore an ordinary phenomenon. This daily recurring change of temperature is one of the principal reasons why the plains of Soudan are not habitable for the Caucasian race; to which we may probably add, that though the malarious substances which produce the deadly alternations of tropical fever are more widely distributed in Soudan than elsewhere, and their noxious germs are carried unchecked over large tracts of land by the trade-winds, the constant recurrence of a high and feeble activity of the skin, by which the ordinary course of the vital functions is checked, paralyses the strength which might otherwise offer effectual resistance to the fatal malaria. But it is strange that the question, "When is the malaria most to be dreaded?" receives the most contradictory answers from travellers. The rainy season is most dreaded on the Niger, and in Sennar, while Burton considers it the healthiest time of the year in equatorial districts.

One chief feature of the flora is the rich development of grasses, both as to variety and the number of individual specimens. Their leaves are generally hard, and hold out for a while against the dry season, but then die off. It is therefore no injury to the soil of the boundless savannahs which are so frequently met with in eastern Africa, when the negro, eager to gain some small tracts of arable land, burns large stretches of withered grasses; for, as soon as the rains begin, new life bursts forth with amazing rapidity from the plant organs underground.

The height of these tall grasses often exceeds six feet; and we read in Barnim's Travels through Sennar, that a full-grown giraffe is hidden from sight by the grasses, only stretching out its head and part of its long neck from time to time. One of the most remarkable of these grasses is the *adar*, so characteristic of the forest clearings on the Nile, with its wide



Baobab (*Adansonia digitata*).

curved leaves and stem, fifteen to eighteen feet high, perhaps the tallest grass known, except the wooded types. The savannahs are rarely connected meadows, but the masses of grass which look like a field of ripe corn at a distance, are found upon a nearer approach to be separated into tufts with patches of bare ground between.

"The water-side (says Stanley) is covered with thick wreaths of high reeds and sedges, and on the surface of the rivers rest the pistias and lotus flowers. The papyrus is found near the Victoria Nyanza and the White Nile, often side by side with the ambak or cork shrub (*Herminiera elaphroxylon*); a leguminous plant with succulent feathery leaves, whose stems rise quickly from twelve to fifteen feet above high water, and die down to the root again upon the dry ground. A horrible loathsome stench rises from these reed thickets; every terror in nature is crowded together: boas overhead, venomous snakes and scorpions underfoot, thorny euphorbias on the path, with stinging ants; and where the path ceases, black mud, knee deep, and a jungle so impenetrable that a leopard cannot crawl through it, or the great strength of an elephant break it down."

The growth of European forest trees, or the upward soaring forms of the gloomy American high woods, must not be looked for in Africa. Timber is scarce, but most of the wood is very hard, especially the African teak (*Oldfieldia Africana*). The relative shortness of the African trees is remarkable. One of the tallest trees is the ceril-cedro (*Khaya senegalensis*), allied to the mahogany tree, and often found more than ninety feet high. In the dense forests of the coasts, on the watersheds of the Congo and Zambesi, many trees with straight stems seventy feet high are found, because there is running water to assist their growth; but in the plain, where the atmospheric rainfall is the only moisture available, they are low and stunted. In the clearings of the western slopes of the Abyssinian highlands, the height of the trees varies from twenty-two to forty feet, and the acacias of the savannahs often degenerate to low and dwarf-like shrubs. Although the action of short rainy seasons is perceptible in these circumstances, it is the more singular to find that some trees are distinguished by disproportionate height and the

Encampment under a Sycamore Tree (*Ficus sycomorus*).

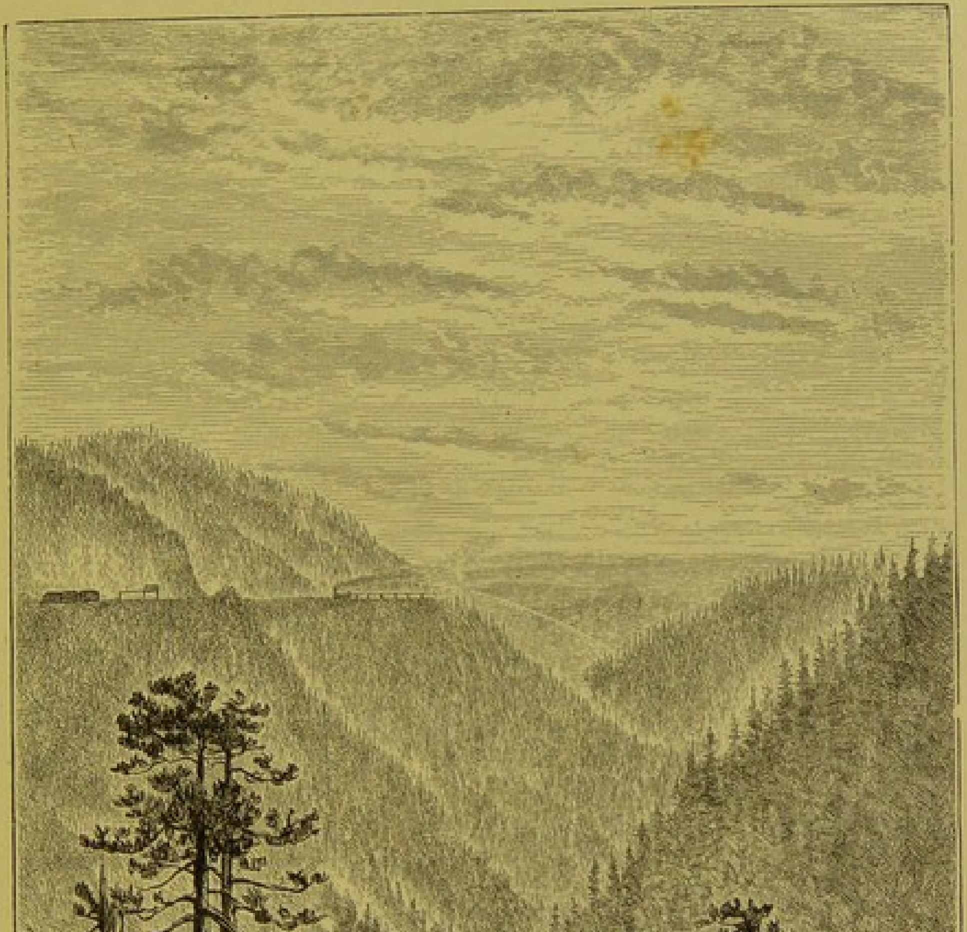
colossal circumference of some of their organs, and that these trees being dispersed across the widest spaces, form a typical feature of African scenery. The most remarkable of them are the baobab tree, the kigelia, and the pisang. These forms, which develop into shapeless magnitude, cannot be explained by climatic peculiarities, but are only to be compared with the no less colossal forms of the African fauna, the elephant, rhinoceros, hippopotamus, giraffe, ostrich, and crocodile.

The trunk of the baobab (monkey bread tree, *Adansonia digitata*) attains near the ground a diameter of twenty-one to twenty-four feet, while the vaulting roof of leaves and branches is often only from sixty to seventy-five feet high. Upwards the trunk gradually becomes narrower until half-way up, and still nearer the ground it breaks up into large thick horn-like branches, which only carry their scanty hand-shaped foliage at their extremities. The curious part of this stem formation is heightened by strong ribs which descend from the principal branches, swelling out larger near the ground; they do not develop until the tree has attained a certain age, when the burden of the crown increases, and the more richly developed foliage forms larger quantities of so-called reserve substances which are stored up in the trunk for occasional use. Werne calls the baobab a shadowless ruin, a comparison which seems all the truer, as the stems often die off inside, and the tree is perfectly leafless for a long time; for instance, in Sennar, from December to June. Then the foliage breaks out, numerous long-stemmed, white, mallow-like blossoms of about six inches and a half in diameter cover the crown; but long after the foliage is fallen the cucumber-like fruits hanging down from the tree, like the nests of weaver birds, on their thin stems, about two feet long, give to the tree a peculiar character. The leaves of this elephant among plants are used by the natives of Borneo as a favourite vegetable, tasting like cabbage, and the boiled kernels of the velvety-shelled fruit are used as medicine in liver complaints. The giant kigelias, which recall our giant oaks, are at first covered with the full bloom of their purple tulip blossoms, and then with the singular fruits, twenty-four inches long, which hang down from the trees like sausages on ropes an ell long. This is one of the plants which at once fascinate and imprint themselves upon the traveller's memory. No less striking is the ensete (*Musa ensete*), a pisang with gigantic leaves, eighteen feet in length, a native of the valleys of Abyssinia, watered by mountain torrents. To these giant trees may be added the sycamore (*Ficus sycomorus*), and a fig whose foliage often extends over a space forty paces in diameter.

The acacia tribe form a chief component both of tree and shrub growth. They bear many thorns and comparatively few of their feathery leaves. Their crest, as Humboldt noticed, often spreads out like an umbrella, even when the stem is very low; but there are also tall trees to be found among them. Together with the acacias is seen the tamarind (*Tamarindus Indica*), a splendid tree common in Soudan, which combines a simple feathery leaf with the size of the oak.

Schweinfurth writes: "Near to the neighbourhood of Faschoda the tolerably close groves of gum acacias (*acacia seyal*) arrested my attention. In the winter-time a man could easily collect daily a hundredweight of gum arabic; but I saw no one engaged in the pursuit, although the merchants of Khartoum are unable to obtain enough to supply the European market. Beneath the acacia groves, which extend for hundreds of square miles along the right bank of the White Nile, there is one species deserving of special attention; it is equally rich in resinous secretions. I called it the flute acacia (*acacia fistula*), choosing the name from the Arabic term *isaffar*, flute or pipe. The white ivory-looking thorns are wildly distorted by the larvæ of insects developed inside them, swelling near the root to globular bubbles of the size of a walnut. After this mysterious insect has escaped through a circular hole, the hollow thorn becomes a kind of sounding-board, and when stirred by the wind gives forth sweet flutelike tones. In the winter months the leafless forest of the flute acacia, with the chalky spectral whiteness of its branches covered with their inflated thorns, seem as if snowflakes had fallen heavily upon the hollow stems, from which a ceaseless flutelike sound rises like a wondrous incantation."

North Africa possesses only four kinds of palms. The date palm is found everywhere throughout the country; the dwarf palm fringes the shores of the Mediterranean, and the doom palm belongs to Upper Egypt. The northern limit of the latter is at 26 deg. north lat., but a few degrees southwards the Nubian argun, or date palm, is found. Still farther southward, below 9 deg. north lat., a richer palm flora is seen near the sources of the White Nile, consisting of the oil palm (*Elais guineensis*), a date palm (*Phœnix*), a reed palm (*Calamus secundiflorus*), and a cone palm (*raphia*), while the deleb palm (*Borassus flabelliformis*) extends northward as far as 14 deg. north lat. in the valley of the Nile. There we meet for the first time a richer combination of palm vegetation, which reaches its fullest development for Africa in Guinea; for here alone, according to the descriptions of travellers, do the palms claim that important part in the composition of the flora which is accorded to them everywhere in East India and in tropical America, while



VIEW IN THE ALLEGHANY MOUNTAINS.

in the west of Africa they possess more sporadically scattered places of abode. The scenery of Guniea shews tall stems with gigantic leaves by brooks and marshes; among these, three species of palms are particularly distinguished; the wine palm (*Raphia vinifera*) is the most common. Eight kinds of reed palm (*Calamus*) are found scattered through the land, and a few low-growing species are also observed (*Podocarpus* and *Sclerosperma*); besides these we must not forget to mention the valuable prickly date deleb and oil palm.

The deleb palm, sometimes classed as a separate species, and sometimes as identical with the palmyra palm so often seen in the East Indies, is distributed throughout Central Africa, and forms extensive forests along the river banks. Away from the water it is only found in solitary examples. Its stem, two feet thick, and often swollen in the middle, grows to a height of from fifty to sixty feet, and carries a wide crown of leaves measuring from nine to twelve feet in diameter, perhaps the largest shading leaves of the vegetable kingdom. The oil palm is still more numerously represented; it is said to descend the west coast as far as S. Palo de Loando, and on the east coast as far as the Nyassa Lake. Together with the prickly date palm (*Phœnix spinosa*), it forms extensive plantations; so that these two kinds, from their great wealth of individual specimens, fully compensate for the variety of species found upon the opposite coast of Brazil. In Fernando Po the oil palm forms a fourth part of all the forest trees, and in certain places is the only tree seen upon the soil; it grows to the height of more than 2,950 feet, probably the highest level reached by a palm in Africa; since the remaining kinds are generally found in the coast districts, and the cone palm, for example, is only found up to 650 feet above the level of the sea. The flora of the east coast is not so luxuriant; it consists of the cocoa-nut and oil palms, the wine palm, three kinds of Hyphæne, among which are the Ntefa palm, (*H. guineensis*), the deleb palm, the latania or bourbon palm and the prickly date palm. The latter kind comes to complete the palm flora of Africa, with another date palm (*Phœnix reclinati*), seen at the southern point of the continent. The whole vegetal district of the Cape and of the desert of Kalahari have no palm trees.

Oil Palm (*Elais guineensis*). In the background are specimens with the trunks stripped of their leaves.

Let us devote our attention to the oil palm; its stem grows to the height of from thirty to sixty and even to ninety feet. Its leaves, like those of the cocoa palm, are feathery, and in those specimens which are left to themselves remain for a long time on the tree after they are withered. The dead leaves are always carefully removed from the trees which are being subjected to artificial culture, because they render the ascent of the tree difficult. In Monbuttu land the stems of the leaves are cut away about twelve inches above the ground, and this practice of the natives affects the whole vegetal character of the landscape, nay, the flora itself, since the stems of the oil palm present a number of welcome starting points for seedlings and for climbing plants which cling to the jagged surface of the stem. Thus we see the stems of these palms draped and overhung with a vegetation of indescribable grace, as if they were the artificial supports of a well-kept orchid house or fernery. From the joint of every leaf springs forth a colony of the most delicate ferns, often from the same leaf, of the most varied kinds, together with shrub-like fig growths (*Urostigma*), and all interwoven and combined with a close network of creeping, long-stemmed ferns or parasitic orchids. Here and there convolvuli (*Ipomœa*) and yams (*dioscorea*) have a share in the wreath-like drapery of the stem, while all kinds of common shrubs and trees strive to shoot forth from the reservoirs of water deposited by the rain within the hollows of the leaves. They are only successful, however, up to a certain age of the plant; for after a time the perishable supports of the tree rot and give way altogether under the load of the ever-increasing number of parasites, and the whole luxuriant growth, robbed of its support, sinks into ruin. The blossoms of the oil palm are, like those of the majority of these trees, of two sexes; not as, on the date and doom palms, upon different trees, but in separate clusters in the crown of the same palm, while in the cocoa-nut palm both sexes are found in the same flower. The male blossoms hang in long clusters, the female in globular ones, of which the palm bears three or four a year; the fruit developed from them weighs from forty to sixty, and in rare instances from eighty to a hundred pounds. The branching divisions of the blossom are prolonged above the fruit in the shape of stiff sharp thorns. The long fruits are pressed so close together that they flatten each other. They are composed of a fleshy orange-red pulp and a hard kernel,

NTEFA PALM (*Hyphœne guineensis*).

the thick shell of which contains a small stone and the white seed-albumen. The oil palm does not bear fruit until it is about six feet high, and before it has lost any of its leaves. The best oil and the most abundant supply is obtained from the flesh of the fruit. It is of a pale vermilion colour and thick consistency, it composes seventy-two per cent. of the flesh; while the seed-albumen (like that of the cocoa-nut, the well-known copra) yields about forty-eight per cent. of a still more tough and buttery substance. The oil is extracted by the negroes in a very rough and ready fashion. On the Gold Coast the fruits are allowed to lie until they begin to rot, and then bruised with wooden clubs in a little trench paved with flat stones, where most of the oil is collected in the middle. The pulp is then squeezed out by hand, and finally boiled. The Bashaw of Benue contents himself with leaving the fruit to rot under a course of watering with boiling water, and then collects the oils from the surface. It is principally used for cooking purposes, and when fresh is said to be very good, and it has a pleasant refreshing smell like the scent of violets. Some writers describe it as sickly and unpleasantly sweet, and others soon grow accustomed to its flavour, but in a few days it turns rancid. The fruit meets with more general and less qualified approbation; it contains the appetising and stimulating bitterness of the olive; Schweinfurth, indeed, prefers it to the fruit of the olive tree. The kernels used formerly to be thrown away unused. Lately, however, the palm kernels form an important export of the west coast. They are pressed out in Europe, and the remains are used as fodder for cattle. There seems to be no actual culture of the plant in West Africa. The labour bestowed by man upon the tree is confined to cutting off the fans of the palm, which prevent the ascent of the tree, and yet all travellers agree that the tree thrives better in the neighbourhood of human dwellings, round which groves of palm trees are gradually formed. It is well known that the palm oil trade of the inhabitants of Guinea has amply compensated them for the loss incurred by the suppression of the traffic in living ebony, as the slave trade has been euphuistically termed. In the year 1876 the German empire imported 207,000 cwt. of oil, to the value of £372,500, and 565,000 cwt. of palm kernels, to the amount of £33,900.

Tree-like lilies (*Dracæna*) grow in Upper Guinea and in the Canaries. Physiognomically allied to them, but systematically different, the gibarra tree (*Rynchopetalum montanum*), a dicotyledonous plant allied to the lobelia tribe, indigenous to the highest mountains of Abyssinia and Schoas, with a hollow wooded stem from six to fifteen feet high, bearing a rosette of sedgy, red-veined leaves, from which a colossal cluster of blossoms rises. Fern trees are very scarce. Tree-like wolf's-milk growths (*Euphorbias*) and aloes represent the cactus and agave of America; they are not numerous, but are distinguished by their size and curious shape, and their light green brightens the landscape in the dry season. A Nubian euphorbia tree (*Euphorbia candelabrum*), the juice of which is used to poison the arrows of the natives, grows to a height of thirty feet, and its branches spread out to a considerable width; still taller is the Abyssinian species (*E. Abyssinica*). These large euphorbia trees are used, together with the cactus, to enclose the gardens and villages, and it would be an interesting question for research, whether, like the opuntias of the countries near the Mediterranean, they were all imported from America. There are two kinds of asclepiadeæ, which, by their evergreen foliage and their growth, form one of the principal features in the barren landscape; the oschur (*Calotropis procera*), with great egg-shaped leaves, and the leafless septadenia (*septadenia pyrotechnica*), with their broom-shaped twigs. Thorny shrubs are found everywhere, some of which, such as the Agal and the *spina Christi*, we have already met with in the desert. Aromatic plants, arons, and bulbous growths are very numerous. The lianas and epiphytæ of tropical Africa are thought by Griesbach to bear no comparison with the floral adornment of the South American trees. There is, however, also a great difference as to the diversity and abundance of the climbing plants between the country near the Nile and the denser forests of the west. In Nubia there are only a few varieties, which recur constantly twining luxuriantly round the trees, but not combining to form an impenetrable thicket. The wooded vineworts (*Cissus*) are most frequently found in the Nubian forests, convolvuli, with richly coloured flowers, grow on the bushes which skirt the banks of the Nile, and gourd plants abound in the savannahs. In the river basin of the Congo, on the other hand, are large woods where the space between the trees is filled up by lianas, some of which are so hard and strong that the traveller is obliged to cut his way through with an axe. The coast terrace of Angola is covered here and there with magnificent virgin forests, where the soil is covered with luxuriant ferns, and within which Welwitsch collected an unusually large number of different kinds of closely intertwining lianas. Climbing palms are only found upon the west coast, and in the neighbourhood of the equator. *Loranthaceæ* are more frequently found than any other kind of epiphytæ. Orchids appear to be rare.

Schweinfurth, in his journey across Khartoum to the heart of Africa, discovered and accurately described the boundaries of the botanical subdivision between the tributaries of the Upper Nile and of the Schari.

"Here (by the Mansilli rivulet) I found a small, a very small fragment of a primeval forest with giant fig trees (the so-called gum tree). But now, as the forerunners of the greater surprises awaiting me, came the reed thicket (*Calamus rattan*, or Spanish cane), which deserves the first place in a description of the coast woods of the Niamniam territory. It was an avenue, a leafy corridor in miniature, a copy on a small scale of the far grander ones to be seen southward of this place, near most of the smaller streams. The flora exhibits to the naturalist most of the plants already familiar on the western coast of tropical Africa; from Gaboon, the Niger, and Gambia, it crosses here the boundary of the watershed separating the Nile basin from that of the Tsade, and reveals to the traveller journeying from the north the undreamt-of glories of the inner wilderness of Central Africa. Although these glories are but a faint reflection of the lavish splendour of the Brazilian virgin forests, yet, from their contrast with the preceding barrenness, the magical effect produced was no less great. At first came hundreds of miles of barren waste, through which the wanderer had to pass, which slowly changed before his eyes into the wide, treeless steppes overgrown with patches of grass; from these he passes into the pleasant region of the shrub woods, where the bushes throw off the wretched vesture of thorn and bramble worn in the desert, to be robed in the soft foliage of their true home. Now for the first time we tread what may be truly named the virgin forest, the forest of Robinson Crusoe, or of Paul and Virginia. Among other trees, the first to greet us are dense thickets of pandanus, haunted by the grey parrot and the chimpanzee.

The fauna of the Ethiopian region is highly characteristic; the region comprises Central and South Africa and Madagascar. It contains nine peculiar families of mammals: the digitalia (*chiromyidæ*), with the aye-aye; golden moles (*chrysochloridæ*), and river martens (*patamogalidæ*), ferrets (*cryptoproctidæ*), and civet hyenas (*protelidæ*), hippopotami, giraffes, and a kind of ant-eater (*oryctopinæ*); besides seven peculiar genera of apes: pongas (*anthropopithecus*), with the gorilla and chimpanzee, the colobus, with the guereza and devil ape, the talapoin (*miopithecus*) and the *cercopithecus*, the mangabe (*cercocebus*), theropithecus, and the dog-headed monkey (*cynocephalus*); nine different genera of lemurs, five genera of insectivora, prickly hedgehog (*cente-*

nidæ), and two kinds of elephant-shrewmice (*macroselididæ*), numerous kinds of civet cats, the hyena dog (*lycaon*), the long-eared fox (*megalotis*), with the fenek, the zorilla (*ictonyx*), an animal allied to the weasel tribe; thirteen peculiar genera of mice, and two other kinds. Besides these animals, which, although not particularly numerous, are yet peculiar to the region, we find the lion, leopard, hyena, hyrax, elephant, several kinds of zebra, buffalo, a large number of antelopes, porcupines, armadilloes (*manis*), etc. The peculiarity of the fauna is more strongly marked by the absence of certain groups prevalent in other parts of the old world; an absence which we may explain by the existence, for very long periods of time, of barriers which separated the greatest part of Africa from the rest of the world. The groups not found there are bears, moles, camels, deer, goats, sheep, to which must be added the different kinds of wild oxen and wild pigs. When we reflect upon the singular absence of the above-named groups, and the no less singular presence of other groups, it seems scarcely possible to find a region more sharply defined and separated by its mammal tribes from the rest of the world.

The number of characteristic birds is not so great as that of characteristic mammals: many of the former have been able to fly across the barriers which kept back the latter. There are seven peculiar families: plantain-eaters (*musophagidæ*), mousebirds (*coliidæ*), *leptosomidæ*, and *irrisoridæ*, allied to cuckoos and hoopoos; the insectivorous, *buphagidæ*, and lastly, crane vultures (secretary bird, *gypogeranus*). Many peculiar kinds are found among the aquatic birds, fruit thrushes, flycatchers, shrikes, crows, starlings, and weaver-birds, the latter being especially characteristic. The region is also rich in wattle-birds, cuckoos, rollers, bee-eaters, rhinoceros-birds, and goat-suckers; it is poor in parrots and doves. Sand-grouse (*pterocles*), and francolins are very numerous; together with four genera of characteristic guinea-fowl, the ostrich, and numberless vultures, eagles, and other birds of prey. We find four characteristic families of reptiles, three of snakes, and one lizard; the snake of the desert (*psammophidæ*), the fanged ground snake (*lycodontidæ*), and vipers are numerous, as also are gekkoes, agamas, and chameleons. The crocodile of the Nile, no longer found in Egypt, is indigenous in all the larger waters of Africa and Madagascar. The characteristic fishes have been already mentioned among the fauna of the Nile. Abundantly represented and numerous in their varieties are the groups of butterflies: *nymphalidæ*, blue and red *lycænidæ*, and the *papilionidæ*. Up to the present time about 750 species of butterflies are known, but it may be that the great equatorial forest belt contains many kinds which are yet unknown. Among the beetles are the sand-beetle and carabus (*Cicindelæ* and *Carabidæ*), buprestidan, and especially the rosechafer and the cerambyx; the carabidæ are found in seventy-five special genera; the showy and brilliant kinds, such as the carambyx and rose-chafer in 76 and 262 kinds respectively, 64 of the one and 216 of the other being characteristic forms. Snails are not so largely represented.

The traveller in these regions must not expect to encounter an elephant, a rhinoceros, a giraffe, or a lion at every turn; for, irrespective of the fact that the most striking forms are not native everywhere, the days when the lion, for instance (to begin, as is becoming, with the king of beasts), could be collected in the arena to the number of 600, lie behind us by some thousands of years. Since those days the king of beasts has been forced to retreat more and more before the true lord of creation. Herodotus tells us that during the march of the army of Xerxes into Macedonia lions used to attack by night the laden camels, to the great astonishment of the martial host, since the majestic beasts of prey had never been seen before in that district. Aristotle gives the rivers Ressus and Acheolus as the boundary of the lion region in Europe, and says expressly that they were never found in any other part of that continent. It is uncertain at what period they were extirpated in our quarter of the globe, but certainly more than a thousand years ago. We learn from the Bible that the lion, that is to say, the Persian variety, once lived in Syria and Palestine, but we have no knowledge as to the date at which it was extirpated in the Holy Land. In every place it is considered as one of the most dangerous enemies of the flocks and herds; man everywhere enters the lists against it, using his strongest weapons of attack, drives it back, and will doubtless extirpate it at last.

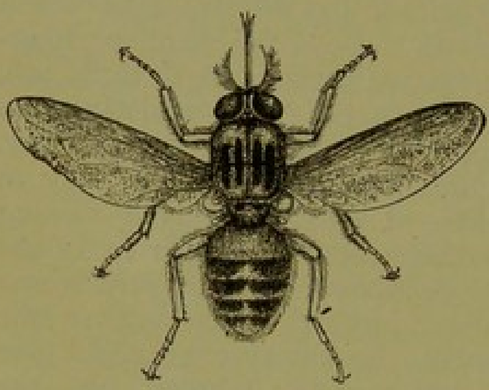
In former days the Barbary lion was known throughout the whole north-eastern part of Africa, and was found in Egypt no less frequently than in Tunis, Fez, or Morocco; but the increasing population, and the spread of civilization forced it to retreat farther and farther, so that it is scarcely to be found at the present day in the valley of the Lower Nile or along the southern coast of the Mediterranean Sea. But even now lions are often seen in Morocco, and are constant visitors in Tunis. In Algiers especially the number of lions has greatly diminished; the frequent wars between the French and the Arabs have driven them away, and the French lion hunters, especially the famous Jules Gérard, have considerably thinned their ranks. Circumstances are much more favourable for the lion of Senegal; the native, armed only with the lance or the poisoned arrow, and only by exception with the gun, can stand but feebly against the attacks of his chief and most terrible tax-gatherer. And yet even the black man is slowly causing the lion to retreat. Fifty years ago Hemprich and Ehrenberg heard the lion's roar in the forests of South Nubia, not far from the district of Handak; now-a-days there are no more lions to be found there. In the countries of the Lower Nile, they have been rooted out centuries ago, and even in the steppes of Takhas, Sennar, and Kardofan, where they are still occasionally seen, they are becoming rarer from year to year. The same is true of the west and eastern coasts, and of the south of the continent, especially in every place where Europeans have settled. The savage beast cannot resist the cool daring and deadly bullet of the European; nevertheless the wide African steppes still shelter an immense number of lions, and will continue to do so as long as, besides the tame herds, the countless troops of wild oxen, together with hundreds of thousands of cattle, millions of antelopes roam through this vast territory. "In the dry season," writes Mohr, "that is, from May to September, herds of antelopes and quaggas leave the parched solitudes of the Kalahari steppes, or the lonely plains of the Transvaal, to seek the wide grassy plains extending round the bay of S. Lucia, gathering together in innumerable herds as they wander on. These wild herds are followed often by troops of lions. My friend, John Dunn the hunter, told me that, when travelling with Oswell, in the year 1867, through the desert of Anatonga, he met a wandering herd of gnus, mixed with quaggas and antelopes, which, according to his estimation, extended over a space of ground one mile wide, and were thirty-five minutes in trotting past him. Behind the herd came a band of some twenty lions, great and small. The lion's manner of life is quite nocturnal; and it is only when driven by necessity that he leaves his den by day. He is very rarely met with in the day time; sometimes he may be seen in the forests, but only when he has been hunted up and roused from his lair by dogs; and this is why so few travellers have to tell of having met him. At sunset the natives pen their flocks and herds in the secure *seriba* (enclosure), a fence made of the close, thorny branches of the mimosa, and built up more than three yards in height, and about three feet thick, the safest rampart that they are able to construct. The night settles darkly down upon the noisy camp; the sheep bleat after their lambs, the cattle have already laid themselves to rest. A pack of watchful dogs keep guard. Suddenly they break out into barking; they gather together in a moment, and rush out in a body towards a wood. Sounds of a short, sharp struggle are heard; savage barking and low, furious roarings, followed by the cry of victory; a hyena was stealing round the enclosure, and has been driven away, after a short defence, and flees before the watchful guardians of the fold. A leopard would scarcely have fared better. It grows stiller, and the grim sounds die away. The peace of night settles down upon the encampment. The wife and children of the owner have sought and found their nightly rest in a tent. The men have finished their work, and betake themselves to their beds. In the nearest trees the goatsuckers hum their nightly song, or carry along their feathery train through the air, often approaching the seriba, and hovering like spirits over the sleeping herd. All else is hushed and still. Even the yelping dogs are silent, although they never become indifferent or neglectful of their faithful duty. Then all at once the earth seems to groan: a lion is at hand. Now is the time to assert his right to the name of Essed, the 'tumult awakener;' for the greatest tumult and the wildest confusion appear in the seriba. The sheep run like mad toward the thorn fences, the goats bleat loudly, the cattle with loud moans of anguish crowd together in bewildered crowds; the camel, wild to escape, strives to burst all his fetters; and the courageous dogs, which have dared to face the leopard and hyena, now break out into piteous howls, and flee whimpering to seek the protection of their master, who, at his wits' end, doubting his own strength, and bowing before the tremendous force opposed to him, trembles within his tent, dares not encounter his terrible foe with only a lance as his weapon, and is obliged to look on while the lion comes nearer and nearer, adding the terror of his gleaming eyes to the terror of his awful voice, and makes good his second name of the 'destroyer of the herds,' or, as the Arabs have it, '*Sabaa.*' With a powerful spring the terrible invader leaps the thorny rampart to select his prey. A single blow of his strong paw fells an ox two years old, and his first bite breaks the neck of the unresisting animal. With a low continuous growling the lion falls upon his prey; his fierce eyes flash with greed and triumph, his tail lashes the air. He relaxes his hold of the dying creature to seize it again with his crushing fangs until it ceases to move. Then the marauder prepares for his retreat across the high fence, not leaving his prey behind. He has to put forth all his mighty strength to leap the enclosure, holding the ox in his jaws. But he succeeds. I myself have seen a seriba nearly ten feet high, over which a lion had leapt with a two-year-old ox between his teeth. I have seen the imprint left by the heavy load upon the top of the fence, and the hollow in the sand left by the falling ox before the lion carried him off to the desert. Not until he has made good his retreat can any one breathe freely in the camp."

Africa is also the home of the leopard; the pard, or *leopardus antiquorum*, the kindred of the *leopardus panthera*, the panther of Asia. It is found in every part of the continent. In the days of Pliny and Aristotle, these two creatures were confused together, and yet there is an obvious difference in their marking. The leopard, to name only one distinction, is marked about the shoulders with round spots, where the panther has fringed spots on a ground of a different colour. Distinct from both these is the pard, or long-tailed panther of Sunda (*leopardus variegatus*), known by the length of its tail, which is at least equal to that of its body; while in the other varieties it is not more than the third part. The black panther was, until very recently, looked upon as a distinct variety, but is now considered to differ only in colour from the sunda or long-tailed panther. Lastly, there is a shining dark-brown leopard, which only appears spotted when it is seen in bright sunlight; this leopard is the gesela of the Abyssinians. The leopard is one of the most daring robbers; not even the baboon and the porcupine are safe from his attacks; and yet one would suppose that his showy coat would give his victims timely warning of his approach; but any one familiar with the wealth of colour in Central Africa can easily understand the similarity of the colours of the leopard with those of his surroundings.

It is not yet possible to give a more detailed and coherent account of Central Africa; but we may learn something further by following Rohlfs on his journey to Uandula, which is situated in the south of the Tsade. Swarms of flies and stinging wasps tormented the animals, but fortunately they were not so dangerous as the fly called *Nbussoni*, which is said to be often seen in Bagirmi, and to kill a horse with a single sting. From the description given by the natives, this fly must be identical with the dreaded tsetse fly (*Glossina morsitans*). This fly, which is found in certain, not as yet sufficiently defined, districts of Central Africa, follows its victims with great obstinacy, to feast upon their blood, is one of those mysterious insects which, while its bite is harmless to men and the beasts of the forest, and, among domesticated animals, to goats, asses, and sucking calves, is certain death to all other domestic animals.

One chief ornament of the country is the feathery-leaved golumbi tree; next to which ranks the shadowy tamarind, through whose broad roof of leaves no ray of sunshine can penetrate. Round the trees climbs the cactus-like digessa (*Cissus quadrangularis*), which is already found in solitary instances in the north of Kuka, but springs up here in masses, with leaves and tendrils like the vine. From the lower end of the stem, which, when the tree is young, is square and fleshy, and afterwards becomes rounded and as thick as a man's arm, is extracted the sap, which, when mixed with other plant juices, makes that terrible poison, the smallest drop of which put into a wound, according to the negro saying, will occasion almost instant death. Here and there the forest is broken by fields of millet, beans (*Sorghum vuglare* and *Pencillaria spicata*), or with patches of a sour-tasted vegetable, *Hibiscus cannabinus*, or karesy.

Very characteristic of the western coast of Africa, especially of the Congo district, where it thrives the best, is the goro, a plant like the coffee plant, with large succulent leaves. Its fruit, the goro-nut, is divided into the true, or *Sterculia acuminata*, and the false, *Sterculia macrocarpa*. The former has a dark-red kernel, with a pleasant, bitter-sweet taste, and consists of two sorts, one containing no mucous substance, and the other containing a large quantity of mucous substance. The false goro-nut, which is only found in the immediate neighbourhood of the coast, is white inside, and only very slightly bitter. It is only the fresh nut which is called goro; the dried nut, with its wrinkled shell and red-brown kernel, is called kola. Although the latter gradually loses its pleasant, aromatic taste altogether, yet it is chewed by the natives of North and Central Africa, and is considered by them as great a necessity of life as tea and coffee are among other nations. The kola-nut is doubtless a stimulant, and a means of exciting the appetite, and contains more *caffeine* than an equal quantity of coffee berries. Along the African coast a white nut costs a shell, a red nut five shells; but, when the caravans have been delayed in bringing in fresh supplies, the price of a single nut rises in Kuka sometimes to one thousand shells (ninepence). In times of scarcity like these a nut is cut up into minute parts, which are presented among friends, and it happens not unfrequently that a rich person will take a half-chewed piece of nut out of his mouth to present it to a poorer friend, who will go on chewing it for a long time. The nut plays a great part in the social life of Central Africa. As the Oriental regales his visitor with a cup of coffee and a chibouk, so in Africa the host honours his guest by setting a nut before him, or sharing it with him. The present of a basket of goro-nuts from a ruling prince is a sign of gracious favour; the fuller the basket, and the larger the nut, the more favourable a reception may be expected by the guest.



TSETSE FLY (*Glossina morsitans*).

On one day, from about three o'clock till sunset, great clouds of locusts, probably from the Tintumma, passed over from the north southwards. The general name for locust is kaki; but there are different names for the different kinds, as the desert locust, and those indigenous to Bornu, a yellowish-green, a grass-green, and a smaller kind. All but the latter kind are eaten by the natives; and the grass-green locusts, which generally feed on aromatic plants, have a rather pleasant taste. Quadrupeds seem not to be strongly represented; some of them have probably been forced to retreat from the settlements of the natives. The air, on the other hand, is full of inhabitants. Down from every branch hangs the nest of the weaver-bird, which is open only at the lower end, so that neither rain nor sun can penetrate them. Another little singing bird, the fani, weaves its nest cleverly of the fibres of the cotton tree, which is here certainly indigenous. Among the wild creatures mentioned by Rohlfs on his journey from Tsade to Lagos, we find especially the numerous tribes of ants and termites of Bornu: some of which build vertical turrets from twelve to fifteen feet high, with round openings; the others erect houses of equal height, with no visible opening whatever; others again throw up cones about three feet high, perforated inside like a sponge. Sometimes one finds nests which scarcely rise above the ground, from which broad, smooth paths run in every direction, along which the ants drag their stores of provisions. The buildings of the insects so often seen in East Africa, resembling mushrooms growing on a soil of bare rock, are not found here; but besides the ants which live in houses, there are others which build under trees, so as to secure their nests from the burrowing anteater (*ocycteropus*) by the thick roots of the tree. Whenever this animal comes to an ant nest, it begins operations by carefully snuffing round it on every side, then sets to work and digs, burrowing down into the earth till it comes upon at least one of the principal entrances of the nest. In the termite hills these entrances are generally less than an inch wide, and along them the invader stretches its long sticky tongue, which is soon covered with ants. It then draws it back and swallows them, repeating the process until its appetite is appeased. Very often it seizes with its lips and swallows down hundreds of ants at a mouthful; but in the true termite nests, where millions of insects swarm, it feeds almost like a dog, devouring hundreds at every bite. Thus it goes on from tree to tree, working the greatest havoc among the termites. With the dawning day it buries itself again below the earth, and cares little whether it find its own hole or not, as it can dig its way into the earth in a few minutes, though its body measures seventy-six inches long. No enemy can follow it into its hole, for it casts up the earth behind it with such violence that every other animal is driven back in confusion. Even men find it difficult to dig it out, and a hunter must be prepared to be covered with sand and dust in a few minutes. It is therefore not surprising that Rohlfs observed no burrowing anteater. Another anteater is the quoggelo, forty to fifty inches long, clothed in a perfect armour of close sharp scales; the scaly anteater, or pangolin (*Manis longicaudata*). In Magommeri Rholfs found captive civet cats and ostrich farming.

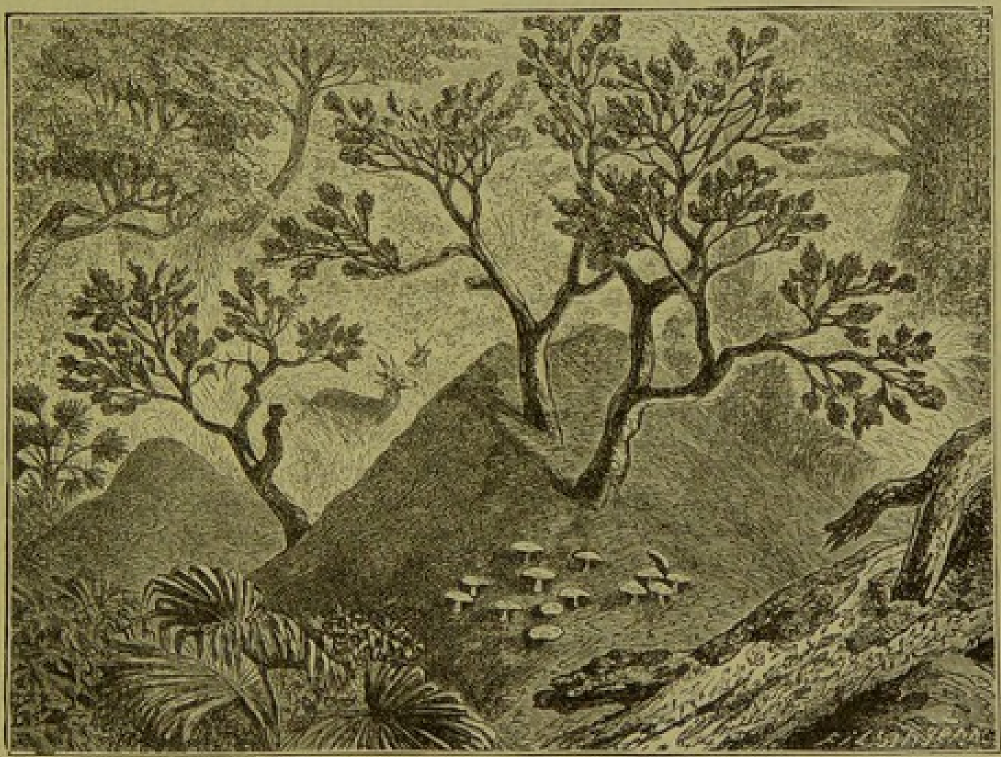
Within an enclosed space thirty female ostriches and one male find their battle-field and breeding place. In seven holes, sunk in the white sand, they lay the eggs, twenty-five or thirty in each hole, on which the hen only sits at night, leaving the eggs exposed by day. Rohlfs and Lichtenstein report that the ostriches lay a number of their eggs outside the nest, and leave them to be used as food by the young birds, until the latter can run far enough to find food for themselves. But this story is based upon an error, as the idea of this kind of food serving for a bird of the nature of a fowl is hardly possible to be believed. Once a year the birds are stripped of their feathers; but although the trade is certainly lucrative, only one ostrich farm was seen by Rohlfs during his travels in Africa. In Kuka and other districts of Bornu, ostriches run tame through the streets, but there was nothing like regular ostrich rearing; while in the Cape ostrich farming has attained considerable importance. When the ostrich is caught young, it soon becomes accustomed to the presence of men. Mahu tells us that he bought two birds on his way to the Victoria Falls, and after taking them with him for some distance he sold them to a caravan; but months afterwards the birds knew him again. In a wild state the ostrich lives chiefly on plants, but it does not despise animal food, and will eat lizards, locusts, small birds, etc. The ostrich is found from the south of Algeria, until deep into the Cape; but it only exists in great numbers in the steppes south of Sahara, and avoids altogether the mountainous districts, such as Abyssinia. It was probably more widely spread in Asia in time past, but even now it is found, though rarely, in the desert land near the Euphrates, in Arabia and Persia.

"The civet cat (*Viverra civetta*)," says Rohlfs, "was kept in a narrow cage. A pole was passed through the grating to tease the animal. It was then firmly seized by a man who presses the civet gland in his hand, turns it inside out, and scrapes off the stinking white fat with an ivory staff. The gland is then rubbed with butter, probably to alleviate the pain, and the fat is placed in a small leather box. At the expiration of a few days it turns reddish, and the colour becomes gradually darker. Civet is no longer in use among ourselves, but it is still the favourite perfume of the Mahommedans, and is paid for with its weight in gold. The principal home of this interesting creature is found in Upper and Lower Guinea.

The character of the Gold Coast, in the neighbourhood of Atra, is described by Buchholz as rather monotonous. The plain extends from eighteen to twenty miles to the foot of the mountain. It is a grassy steppe covered with low bush and a few isolated trees, with a little badly cultivated land near the villages. Manioc (tapioca, *Jatropha manihot*), and yams (*discorea alata*), bananas, and other vegetable food, do not thrive near the coast at all, but are brought from the villages near the foot of the mountains, or from the mountains themselves, where the soil is more fertile, and the plants more abundant, to Atra. The scenery receives its special character from the abundance of euphorbias, the commonest kinds of which met with in the district are large candelabra-shaped plants, and others with large fleshy leaves.

"In the steppes round Atra there are great numbers of termites, and their hills make a feature in the scenery. They rise in cones of hard clay from seventy to one hundred and twenty inches high, scattered on all sides between the bush and grasses. One exceptionally large termite hill was a regularly formed cone, and had at the base a circumference of thirty paces. These large termite hills have a rather thick solid crust, with no cells, so that they cannot be opened without hatchet and spade. Many of the mounds were opened without any termites being found inside them. Nevertheless they presented a special interest from their affording an admirable place of shelter for all sorts of reptiles and insects. Ants, wasps, bees, spiders, a fine snake, and other creatures were found in abundance. But when the top of one of the inhabited hills was broken open, the soldiers rushed out at once to defend the building, while the little working ants retreated toward the interior. The soldier ant is three-fifths of an inch long, with a flat square-shaped head, which, with its powerful projecting mandibles, one-twelfth of an inch in length, took up fully half the length of the whole body. The workers were less than half the size of the fighting ants, and had round heads. Inside the anthill we found strongly built columns made of clay, supporting the outer walls, and leaving a space between them in the centre. They were like twisted spiral plinths, and contained smaller chambers within them; still smaller rooms were immediately connected with the columns, and communicated by means of holes with the centre hall. All these inhabited tubes were more or less damp, and on opening one of them an unmistakable smell of the acid distilled from these ants was observed. After a great part of the hill had been opened, the naturalist left the place, and returned in an hour's time. By that time a crowd of working ants were busy in repairing the damage done to their homes, and stopping up the broken places. They had already thrown up vertical walls of clay, which reached half-way up the opening. Each worker carried in his mouth a tiny pellet of clay, which he laid upon the wall, and pressed firmly down. The soldiers took no part whatever in the work, but stood sentinel in the different corridors, or stretched their long heads over the wall, ready to rush out at a moment's notice, if the workers were attacked. On the following day the holes were all stopped up, but the ants seemed to have left the hill, the soldiers had disappeared, and only a few solitary workers were seen when the hill was explored further. The work led to no other result; for when the whole structure above ground was carried away, neither winged insects, nor queen, nor eggs could be found."

The territory of Aburi, a few miles inland from Akra, has been already subjected to a certain kind of civilization; tilled land, and plantations are seen on all sides in the clearings between the forests; but the coffee plantations are devastated by the destructive teredo, or burrowing worm. Ever since the negroes have been provided with guns, the larger wild animals have, to a certain extent, diminished; parrots and apes also, which abound in the untouched virgin forests of the neighbouring territory of Akmia, are seldom met with here. The insect fauna, however, is very rich. In the first rank come the migratory or travelling ants, which, if not a national pest, may often be called the scourge of the village or the house. One large black species march in close lines, often right across the most frequented paths, and penetrate within the houses, where they do incalculable damage in the course



TERMITE HILLS.

of a single night. A credible writer, Wiedemann, a missionary at Akropong, declared that these ants devoured five of his young turkeys in one night, and he had been told of their having killed and partly eaten a tethered wether. Buchholz himself witnessed the expulsion of snakes from their holes by these ant armies, and a solemn meeting in the mission church was suddenly broken up by the same means. Great efforts were made to discover the nest of these ants, but without success.

Although a great number of elephants' teeth are shipped every year to Europe from the west coast of Africa, yet we learn from the narrative of Oscar Lenz that in the lands adjoining the sea coasts elephants are almost extirpated; occasionally, but very rarely, a few scattered specimens are seen in the closely wooded districts round the mouths of the great rivers. The large herds are now only met with on the coast of Malimba, which extends from the equator to 5° N. lat., where they are frequently seen near the negro villages and the few factories; for now that European settlements have been established on the different parts of the coast, and a regular and orderly system of barter has superseded the slave traffic which used to be prevalent everywhere, such a war of extermination has been carried on by the natives against the elephants, that the traveller has to penetrate far into the interior to find the pachydermata. But there are still numerous elephant herds to be found in the immense wooded districts of Ogowe.

The elephant is generally hunted with guns; spears are much less in use. Lenz gives a description of one of these hunting expeditions. A scaffolding was built out from a tree, at a good height from the ground, and a man armed with a strong spear, about twenty-eight inches long, inserted into a stout stake, from four to five feet in length, took up his position upon the platform. The hunter, a Mbangwe, held his powerful weapon with the spear point turned downward; the other men tried to drive the elephants underneath the tree. When this is done, the hunter plunges the spear with all his might into the animal's body, a difficult manœuvre, but so successful this time, that the young fellow brought down his unwieldy prey at the first stab, when its life was soon ended. The hero of the day was naturally very proud of this exploit, and brought to Lenz as trophies of the chase one of the enormous ears and the long tail of the elephant, which were then given over to the medicine man. The flesh, which is readily eaten by the negroes, is not relished by Europeans. Lenz, as the guest, was presented with the trunk and feet, which are considered as the best parts, and his curiosity induced him to taste the meat after it had been boiled for many hours; but he found it impossible to find out the good qualities of the tough mass, and gave it all to his servants.

As for the geographical distribution of the African elephant, it is certain that in former times it inhabited the greater part of Africa, with the exception of the deserts. It was even known to the inhabitants of the north coast, as is proved by the coins of Cyrenæ, and it is very probable that the African species was the only one used by the Carthaginians in their military campaigns. Even at the present day the animal is found throughout Central Africa, always excepting the deserts. In the north it wanders as far as the boundaries of Sahara, in the south as far as the Cape, from which country, however, it was almost entirely extirpated towards the end of the last century. According to Henglin, it still inhabits in great numbers the virgin forests and marshes of the river basin of the White Nile, where, however, it finds no settled place of abode. In the rainy season it retreats to the drier, higher-lying districts. In the hot season the animal comes to the rivers and marsh lands, for water is an essential necessity to the elephant, both for slaking its thirst, and for bathing and sprinkling the skin, which it cleans and keeps with extraordinary care. It is said that bands of elephants comprising five hundred animals are often met with. The principal time of the year for assembling in troops depends upon the season or the failure of food, which obliges them to forsake their favourite haunts. When once their march has begun, nothing seems to offer them any obstacle; they swim across lakes and rivers, work their way without difficulty across wide marshy tracts, and trample down broad pathways through the densest forest. Their constant companions are a species of heron and a wild boar (probably *Sus senarensis*). When they are hunted in any district, countless numbers of vultures immediately appear, although no trace of them may have been observed before. Although elephants are found in such numbers, yet it is often very difficult for the hunters to track them to their resting place. Their march is generally so quick, that it is almost impossible to keep pace with them, and when once they have escaped, the hunter seldom attempts to pursue them, as there is little hope of the chase being successful. The highly developed mental qualities of these pachydermata are fully appreciated by all the negro tribes. Many Mussulmans of the south maintain that the elephant is the primeval father of the human race, and on that account refrain from eating its flesh, while the negroes, although accepting the belief that they are originally descended from these monsters, yet hunt the elephant especially for the sake of procuring its flesh, the teeth and tusks being of less value to them, as they are almost always claimed by the chiefs of the tribe, as their special portion. Rohlf tells us that the countries by the Benue furnish by far the greater part of the ivory which is brought, *viâ* Tripoli, into the European markets. The sultan of Kephi undertook to procure 50 cwt. of the largest elephants' teeth within the space of a few weeks; but Rohlf had no time to spare, and perhaps was running short of money: he purchased, however, two elephants' teeth, weighing both together 140 lbs., for 229,000 shells. That number of kauri shells represented a value of £6 12s. A dealer would only have paid £4 10s., or at the most £5, for the teeth, and in Europe they would have been worth £32 10s. Five small teeth were sold to Rohlf at the low price of 60,000 shells.

Next to the long-eared elephant we have to speak of the kindred rhinoceros, allied to the elephant by its thick skin. The African rhinoceros is distinguished from the Asiatic by its smooth skin, which is only wrinkled at the neck. Two horns, placed one behind the other, adorn its nose. The constantly irritated two-horned or black rhinoceros (*Rhinoceros bicornis*) is the best known type, and is distributed throughout the whole of Central Africa. The harmless flat-horned or white rhinoceros (*Rhinoceros sincus*) is the largest species, and measures, without the tail, 14 ft. 1 in. in length. This animal is principally found in the south. The extreme irritability of their thick skin is very remarkable; even a fly which settles down upon it being immediately shaken off by a convulsive movement; and in order to escape as far as possible from the attacks of insect pests, the unwieldy beast is seen rolling in the mud until it is covered with the temporary protection of a coat of slime.

The rhinoceros-bird (*Buphaga erythrorhyncha*) is the constant companion of both kinds of rhinoceros, and of the hippopotamus. It feeds upon the parasites which swarm on these animals, and is always found in their immediate neighbourhood or upon their bodies. "Very often these guardian birds," Cumming tells us, "which are always on the alert, have frustrated my most careful attempts to approach the rhinoceros, and caused me to spend all my labour in vain. They are the animal's best friends, and seldom fail to rouse it from its deepest sleep in case of danger. The old fellow understands their warning perfectly, springs to its feet, looks round in every direction, and invariably makes its escape. I have often hunted the rhinoceros on horseback, and have been obliged to follow it for several miles, and to expend upon it a number of bullets before it fell. Even during the pursuit the birds remained with their patron and bread-giver. They sat on its back and head; and when a bullet entered its shoulder, they rose up with shrill cries to the height of about six feet, and then settled down again into their former position. Sometimes it happened that the lower branches of the trees under which the rhinoceros passed swept away the birds, but they always found their place again."

The *Hippopotamus amphibius*, or river-horse, abounds in all the larger sheets of water in Central and Western Africa.

Lenz says: "How often in my canoe voyages have I seen the ugly head of the colossal beast emerge from the surface of the water! and how many bullets have we not expended, not so much in the hope of killing the beasts, as to frighten them away, because canoes are very often upset by the awkward monsters. I have often myself seen a great hippopotamus suddenly rise up close to my canoe, and brush against the side, so as to spring a great leak, into which the water immediately rushed. The animals are never hunted by the negroes so long as they remain in the water, but at nightfall they generally come to feed upon the shore, wherever a narrow strip of grass land is found between the forest and the river. The hunters then try to cut off their retreat to the water, and to drive them into the woods, where they are killed with spears and guns. The flesh is eaten, and I have often bought large quantities of smoked hippopotamus flesh for my escort, which sometimes amounted to more than a hundred men."

Another curious and interesting mammal is often found in the brackish lower course of the rivers. This is the manatus, an animal belonging to the siren tribe, measuring about seven or eight feet in length, and closely allied to the lamantin (*Manatus australis*), so frequently found along the coasts of South and Central America. The manatus is called by the natives *manga*, and is hunted for the sake of its flesh, and killed with a harpoon. The natives of Gaboon River district manufacture from its thick leathery skin the *kassengu*, or large whips, used in the factories for the correction of idle and thievish workmen. This insignia of justice is also made from the skin of the elephant and the hippopotamus. The European traveller who is forced to provide himself with food by his rifle in the chase wastes no thought upon the manatus, because its flesh is not to his liking; he devotes his attention chiefly to the wild oxen, wild pigs, and different kinds of antelopes which provide him with eatable food when there are no tame creatures, such as goats, sheep, fowl, and fish, to be met with. The latter case, however, is seldom experienced, for domestic animals are sure to be found wherever there are negro settlements.

The wild ox is the same as the short-horned breed (*Bos brachyceros*), also found in East Africa. The wild pig, which is also found, and frequently makes its appearance in herds, is known as the long-eared pig (*Potamochœrus Africanus*). Its colour is a dark yellowish red; it is rather smaller than our own wild pig, and is characterised by its long pointed ears. The flesh is pleasant as food, and is liked also by negroes. The wild pigs are generally caught by the help of spears and pits dug to ensnare them. These traps make certain parts of the woods rather dangerous to walk in, and the traveller has to submit blindly to his guides, who are taken from the adjoining neighbourhood, and who know exactly where such traps are laid. In the east and the south, this "most beautiful of all possible pigs" is replaced by the bush pig (*Potamochœrus Africanus*), while the whole of Central Africa is the home of the clumsiest and ugliest of all known bristly animals, the wart-hog (*Phacochœrus Africanus*).

There are at least ten kinds of antelopes in the forests of Gaboon and the district of the Ogowe, from the elegant little dwarf antelope, which stands scarcely twenty inches high, to the white-striped antelope of Bango, which reaches the size of a fallow deer. Large herds of these animals, which are so frequently found in the open plateaus of Central Africa, are naturally unknown in the dense woods of the western part of the continent. Lenz sometimes met antelopes in pairs; but from the exceptional character of the animals, their extreme shyness and speed, they are very hard to capture in the chase, and even the negroes generally catch them only in pits. Indeed, a successful hunt, with a large amount of booty, is a very rare occurrence. Although the woods are filled with game, the traveller seldom comes across them, and it is a mistaken notion to imagine that one has but to enter the high woods of the tropics, and fire away right and left, in order to bring home an abundance of food. This is not the place for a detailed list of all the large and small animals hunted in the chase; but we may mention that a great number of animals which are found both north and south of the equator in

Western Africa are utterly unknown to Europeans even by name. Neither the lion nor the giraffe is found; and both ostriches and hyenas are conspicuous by their absence. Of the larger beasts of prey, the leopard is the only one represented; it is met with all along the west coast, and is erroneously termed a tiger. It is very abundant in certain districts, and particularly dangerous to the herds of goats and flocks of sheep belonging to the factors and the negroes; indeed, it sometimes attacks men. When Lenz was spending a few days in a village of Banschaka, it happened that a woman who went late at night to a well about half a mile from the huts did not return, and on the following day evident traces of the disaster were discovered. It was, as usual, firmly believed among all the negroes of the west coast, that the event was not in the natural order of things, but that some one in the village, transformed into a leopard, had devoured the woman. The family of the unhappy woman went to the priest and magician (*oganga*) of the place, who soon discovered the culprit, and sentenced him to eat *n'kassa*, the poisonous bark of a tree (*erythrophlæum guineense*), which paralyses the action of the heart, and occasions certain death if it is not speedily expelled from the system. The negroes eat everything in the shape of flesh, except the feline beasts of prey. Some of the smaller kinds of felines are as dangerous to poultry as are the large species of falcons and eagles. With respect to several kinds of flesh which are considered by us to be uneatable, we may say that not only are the different kinds of monkeys, porcupines, large rats, crocodiles, and other creatures, used for food; but also the flesh of a long and thick python is much relished in Okanda. This snake, which measures more than twelve feet in length, is rather scarce, being found far less frequently than the small, poisonous adders. It is very singular that the negroes of Ogome do not understand the milking of their domestic animals, and were above measure astonished when Lenz's servants milked the goats, and gave the milk to their master; and the same writer tells us that the negroes often surrounded him in crowds to see him eat hens' eggs, a diet quite new to them, although they ate numbers of the large round eggs of the turtle, and the still larger crocodile eggs.

CHIMPANZEE (*Anthropopithecus troglodytes*).

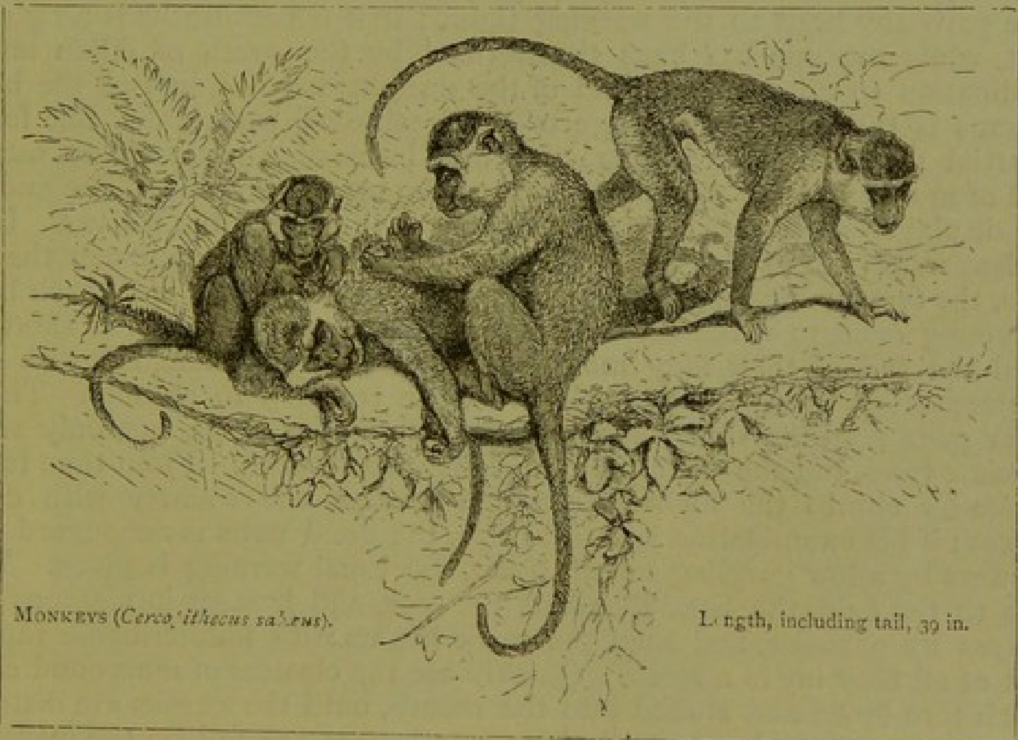
Mosquitoes abound everywhere; and next to them ranks an insect which has only been known in Africa during the last ten years,—the sand flea (*Bicho* or *Rynchoprion penetrans*), which is said to have been brought by the crew of a Brazilian ship who were suffering from them. They multiplied with incredible rapidity. The animalculæ enter the skin beneath the toe-nails, where they lay a bag of eggs as large as a pea; and the difficulty is to remove this bag without breaking it. If this is done, the wound soon heals; but if not, painful sores are the result, and the process of healing is very slow. Another interesting insect is the giant beetle, Goliath (*Goliathus giganteus*, or Druryi), an insect resembling our rosechafers in form, but measuring nearly four inches. This black velvety beetle, marked with white on its upper side, is at home throughout all Africa; and, with its kindred types, forms one of the principal treasures of our collections, being so much in request that £5 is paid for a fine specimen.

The most interesting animals of these countries are beyond all doubt the gorilla (*anthropopithecus gorilla*), and the chimpanzee (*anthropopithecus troglodytes*). The gorilla is the largest of the man-like apes, an animal rather shorter, but considerably more broad-shouldered, than a strong man. Although the gorilla was mentioned more than 2,000 years ago, by Hanno, the commander of a Carthaginian fleet, it is even now very imperfectly known. In the first place, the statements of travellers, who claim to have observed the ape in its true home, within the untrodden forests of equatorial Western Africa, are absurdly exaggerated, and we shall therefore not find room for the sensational stories which relate how the angry animal attacks its enemy, the huntsman, throttles him, flattens the barrel of his gun with its teeth, and other similar fables; but if the statements respecting the strength and savageness of the gorilla are only half true, there is little prospect of ever being able to bring over full-grown specimens to Europe; and the young gorilla presented to the zoological garden of Berlin unfortunately fell a victim to the European climate. Even the skin, skeleton, and remains of the gorilla preserved in spirits, are ranked among the greatest treasures of our Natural History Museums. The second representative of the African man-like apes is comparatively frequent, and is well known in Europe under the name of the chimpanzee, though few full-grown specimens have been brought to this continent; it is much smaller, slenderer, and more elegantly built than the gorilla, and often measures sixty inches in length. Its scanty covering of hair is of a dark olive shade, the face being hairless and fresh coloured. While the gorilla frequents the densest woods, and is only found in the lands near the coast, the chimpanzee inhabits the whole of the West African subdivision, and seems to prefer being near the open clearings of the forests; both kinds of ape feed principally on fruits, nuts, and the young shoots of trees, perhaps also on roots. As to the mental qualities of the chimpanzee in captivity, much has been written, and it is agreed that the animal may be ranked among the most highly gifted of its race. It not only learns to know its master, to love its friends, and avoid its enemies; it is not only inquisitive, but actually desirous of knowledge. Any object which has once excited its attention increases in value as soon as it has learned how to use it; the chimpanzee is cunning, self-willed, but not stubborn, desiring what is good for itself, betraying humour and caprices; one day cheerful and excited, another depressed and sullen. When ill, it is patient under the surgeon's knife; and, according to Brehm, if not entirely human, has a great deal of the human within it. It cannot therefore excite our surprise that the natives of West Africa are of opinion that the chimpanzees were once men, who, on account of their bad qualities, have been thrust out from human companionship; and still persisting in yielding to their evil impulses, have gradually sunk to their present degraded condition. Less is known of the chimpanzee in a state of freedom; like the gorilla, it does not live in troops, as do other monkeys, but in pairs, or even alone; it is only occasionally that the young are seen to assemble in larger bands. The chase is difficult. According to the report of the niam-niam, from twenty to thirty skilled

GIRAFFES, OSTRICH AND ZEBRAS.

hunters are required for the pursuit. To them is entrusted the difficult commission of climbing up the trees for more than eighty feet, trying to outdo the chimpanzee in speed, and to capture it in the nets, after which it is easily despatched by lances. When thus brought to bay, the apes defend themselves with savage fury, sometimes snatching the spears from the hunter's hand, and striking out wildly right and left; and even more dangerous than this method of defence is the grip of their pointed teeth, and the amazing muscular power of their nervous arms. Here, as in the woods on the western coast, legends are current of their carrying off human beings, and of the curious nest which it is said they build of leafy branches in the crest of the forest trees.

We must not omit to mention the smaller kinds of apes; for although they are very numerous in all the primeval woods of the tropical belt of Africa, they are principally found along the west coast and near the Upper Nile. The name sea-cats, by which they are sometimes known, was given centuries



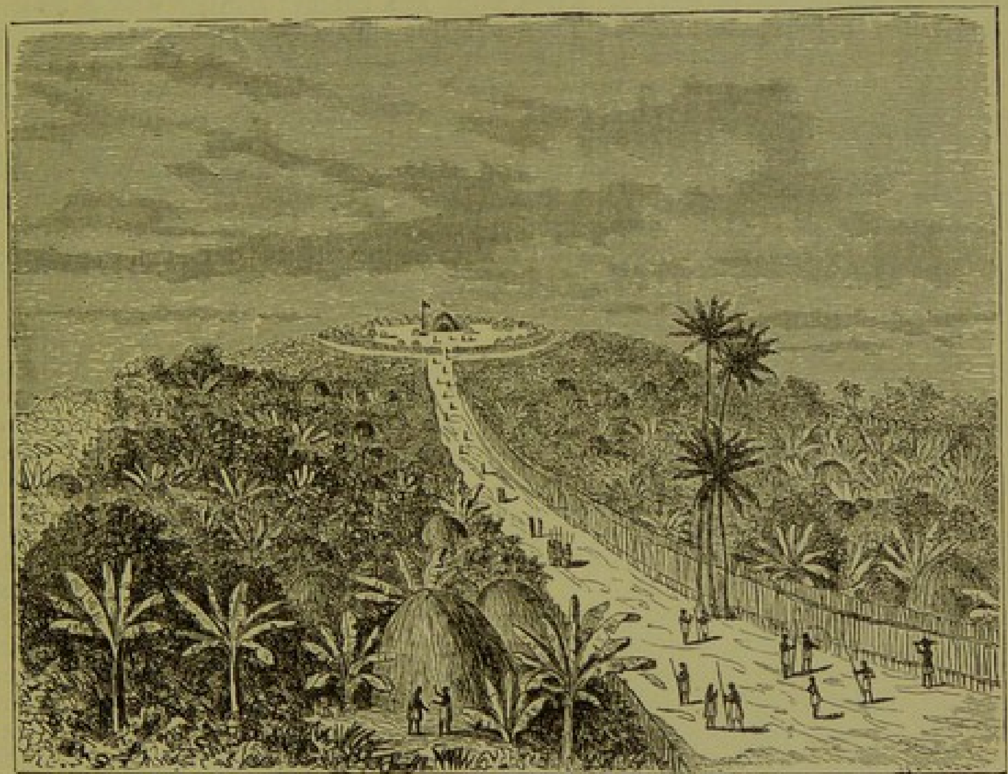
MONKEYS (*Cercopithecus sabæus*). Length, including tail, 39 in.

ago to these merriest and prettiest specimens of the monkey tribe, because they were brought over the sea to Europe, and because something in their shape resembles the cat. The favourites of the children, the nimble, quarrelsome, amusing inhabitants of our menageries and zoological gardens, which sometimes win from the grave man of science a smile, belong to this category. The greyish green monkey (*Cercopithecus sabæus*), the slate-coloured, white-bearded Diana (*Cercopithecus Diana*), the ill-tempered black monkey (*Cercopithecus fuliginosus*), the reddish huzzar monkey (*Cercopithecus ruber*), and numerous other kinds, are included in this family. "It is a real pleasure," says Brehm, who is the best authority on this subject, because he speaks from personal observation, "to meet with a band of these monkeys in the forest; it is a wild chaos of busy life, crying and fighting, quarrelling and reconciliation, climbing, running, pilfering and plundering, grimacing and contortion. They recognise no leader of their commonwealth, except the strongest of their race;

they acknowledge no law but that enforced by the sharp teeth and strong hands of their chief; they consider that no danger can exist from which he is not able to set them free; they adapt themselves to every position, have no fear o drought or famine, and spend their lives in perpetual activity and merriment. Their chie characteristic is the combination of most amusing earnestness with boundless rivolity, which accompanies the beginning and end of all their pursuits. No tree crest is too high, no treasure too safely hidden, no property too respected, for their attacks. It is therefore not astonishing that the natives of East Soudan only speak of them with unutterable contempt and anger. 'Only think, sir, the clearest proof of the godless nature of monkeys may be seen in their never bowing before the word of God's ambassadors: all other creatures honour and revere the prophet; Allah's peace be upon him! The monkeys despise him. The man who writes an amulet, and hangs it up in his field to keep off the hippopotamus, the elephant, and the monkeys from devouring his fruit and injuring his property, always finds that the elephant alone pays any heed to the warning signal; that is because he is a righteous beast, while the ape has been transformed by the wrath of Allah into an abomination to all men; a child of the unrighteous one, just as the hippopotamus is the forbidding image o the loathsome sorcerer.' But for the impartial spectator it is an attractive and interesting spectacle to watch a band of monkeys setting off upon their predatory expeditions. The audacity they displayed used to delight me as much as it enraged the natives. Under the leadership of the old veteran father of the tribe they approach the corn fields, the females carrying their young before them, instead of on their backs; the young ones, to make themselves perfectly secure, twist their short tails round the tail of their lady mother. At first they approached with great circumspection, travelling generally from one tree top to another. The old leader goes first, the others following exactly in his steps, not only seizing the same trees, but the same portion of the same branch. From time to time the leader climbs the highest tree, and surveys the country with careful glances: if his examination is satisfactory, the good news is announced to his followers by a low gurgling sound; if not, the usual warning is given. When close to the field, the band descends the tree, and hastens in vigorous leaps towards its paradise, and then the work begins with indescribable rapidity. First of all they lay in a stock. Quickly are the clusters of maize and ears of durrah torn down and stuffed into the mouth, until the cheeks are distended to the uttermost, and not until these storehouses are full do the marauders allow themselves any relaxation. They then begin to be more particular and dainty in the choice of their food. All the ears and clusters are carefully sniffed and examined after being broken off; and if, as is often the case, they do not come up to the required standard, they are at once thrown away. It may be safely said that of nine clusters which are gathered, only one is eaten; and generally the epicures only take a grain or two out of each ear, and then throw the rest away. All the members of the band place implicit confidence in the care and prudence of their leader. The latter often rouses himself from the most dainty morsel to attend to his duties, standing upright on his hind legs, and looking keenly round. After each survey he announces the result either by the gurgling sound, which indicates that he has seen nothing disquieting, or by the peculiar inimitable quivering cry of warning. When that sound is heard, his followers are gathered together in a moment, the mothers call their young ones, and all are at once ready for flight. The retreat is accomplished without the slightest sign of terror or cowardice; on the contrary, the presence of mind displayed by the whole band is worthy of admiration. Without exaggeration we may say that there is really no danger to be feared by them, if they like to take proper precautions; they can easily avoid wild beasts, and if necessary they can defend themselves against birds of prey; man alone, with his deadly weapon which slays from afar, can subdue and destroy them."

Stanley gives the following description of the scenery of Central Africa:—

"Unyamwezi is a wide undulating table-land, sinking westward toward Tanganika. Any one taking a bird's-eye view of the land would perceive forests, a purple-hued carpet of foliage, broken here and there by barren plains and open glades, extending toward every quarter of the heavens. Here and there rise masses of rocky mountains, towering like blunt cupolas above the gentle undulations of the land, on to the distant horizon. Standing upon any projecting point, a massive block of syenite rising above the mountain crest near Mgongo, Tembo, or the rocky height of Ngaraiso, a scene never before witnessed meets the view. Nothing



KUBAGA, CAPITAL CITY OF THE EMPEROR M'TESA OF UGANDA.

picturesque can be seen; the landscape may be called prosaic and monotonous; but it is in this very overwhelming, apparently endless, monotony that its sublimity lies. The foliage is bright with all the colours of the prism; but as the woods retreat toward the far distance, a silent mystical vapour enfolds them, and bathes them first in pale, and then in dark blue, until they are lost in the distance. But near the lake all is busy life. The shore immediately adjoining the Lake of Ugogo is formed by a morass of at least sixty feet wide, and extending on every side. It is an impenetrable tangle of luxuriant sedge and rushes, where the unwieldy hippopotamus, going his nightly rounds, has left his watery footsteps imprinted in the swamp. Numerous buffaloes, zebras, giraffes, boars, kudu antelopes, and other animals come here at nightfall to quench their thirst. The shores and surface of the lake are alive with an amazing number of aquatic birds—black swans, ducks, sacred ibises, cranes, and pelicans; high overhead, watchful for their prey, hover kites and fish eagles; while the shore is vocal with the loud call of the guinea-fowl, the hoarse scream of the toucan, the cooing of the pigeons, the hoot of the owl mingling with the cry of the snipe and wild fowl rising from the long grass by the water's edge. These shores are also the paradise of the long-legged stork and the heron, the saddle stork (*Mycteria senegalensis*), the *Ciconia abdimii*, the *Tantalus ibis*, the marabout (*Leptoptilus crumenifer*), an ugly bird, in spite of its wonderful and costly feathers, the giant heron (*Ardea Goliath*), etc., while the curious stilt-bird of Africa, one of the most singular birds of the globe, the shoebill (*Balæniceps rex*), inhabits the more northern marshlands, vast impenetrable morasses of the White Nile, and some of its tributaries.

Schweinfurth has written more in detail about the forests in the "heart of Africa," and tells us that the flora of the Djur and Bango lands concentrates all its luxuriance in the first months of the rainy season, leaving the autumn, when the grass of the steppes is withered, to fare less richly. The scenery varies much less than in the most monotonous districts of Germany, but it has nevertheless its alternation of clustering groves of bushes, its clearings with noble trees more than thirty or forty feet in height, its luxuriant undergrowth broken by grassy reaches or copses of tall shrubs.

Who can describe the scene in a woodland district of Central Europe, without speaking of its firs and beeches, alder trees and oaks? But the traveller who is charged with the description of the woods of Central Africa must not content himself with a mere list of barbarous, unpronounceable names. To avoid this difficulty, the celebrated botanist of whom we are speaking has ventured upon an original method of nomenclature in the passage which we subjoin. Here are trees which at the first glance seem to bear a close resemblance to our oaks; to this class belong especially the terminalia and the butter tree (*Bassia* or *Butyrospermum*). The fruit of the latter tree consists of a globular oleaginous kernel, very much like that of our horse-chestnut, and surrounded by a pulpy flesh; the whole fruit is of a pale-green colour, and about the size of an apricot. The flesh is not eaten until it is rotten, like that of the medlar, and is one of the best fruits of the country. From the kernel of this widely spread tree, the oil known as the "butter of Galam" takes a certain importance in the trade of Gambia. This fine tree is distinguished by a bark whose regular markings establish the likeness to the oak tribe, in spite of its contrasting leaves. A tree universally distributed, so like our white beech as to be easily mistaken for it, is the small-leaved anogeissus. Nut trees are represented here by kigelia and odina. The type of our ash trees is widely distributed here; and the horse-chestnut is recalled by certain kinds of the castus tree (*vitex*), whose olive-like sweet fruits are collected by the natives with as much diligence as by the wart-pigs, which are very fond of such food. They find a favourite food also in the fruits of a kind of ebony wood (*Diospyros*). The beautiful sterculia (*Sterculia tomentosa*) is a copy of the platane as to the bark, and also as to the leaf-form and foliage, and is distributed far and wide throughout tropical Africa. Willow trees are represented by the anaphrenia, and oftentimes we fancy we are looking on the acacia when we see the graceful cæsalpiniæ. The parkia is a noble tree, everywhere found in tropical Africa. Its flame-coloured blossoms hang down like globes crowned with a tuft from the long stems; from the blossoms is developed a whole bundle of husks a foot long, the seeds of which are wrapped in a fine yellow flour, rather sweet to the taste. This is mixed with wheaten soup; but it needs an African palate to endure the nauseous taste of the preparation. Other tree forms which suggest no kindred types among our own trees are found in great abundance throughout the forests of Central Africa, and are distinguished, broadly speaking, less by an overwhelming fulness and luxuriance of type than by the constant freshness and grace in the whole cast of the scenery. The custard-apple (*anona Senegalensis*), with its large bluish-green leaves, has nothing European about it. Its small fruit, which seldom ripens, contains a brick-red aromatic pulp, and even in its modest primitive form betrays the seductive charm which exalts its cultured kindred to the rank of queen among fruits. Far grander and more imposing are the colossal candelabrum wolf's-milk growths (*euphorbias*). Palms play a subordinate part in this scenery; the fan palms are found clustered together in groves; and in the marshy steppes grows the prickly date, perhaps the primitive type of the date palm. Then come the leather-leaved fig trees of every kind, and among them the grandest monuments of African vegetation, the sycamores, together with large-leaved combretum and *rubiaceæ*, tamarinds, with dense cylindrical crests, and the dwarf-like stunted shrubs of the *gardenia*, etc.

Very characteristic of the countries of the Bongo, Niamniam, and Monbuttu, are the patches of primeval forests, watered by running streams, and known by the name of galleries. The soil is unusually rich in springs of water, which keep up a perpetual overflow of the brooks; and while in the northern districts the rivers have to find their way across open lowlands where the volume of water soon diminishes, and is lost in the parched earth, the country here is like a well-filled sponge. The result of this abundant moisture is that the valleys and fissures of the earth through which the water flows, whether in the form of little brooks and streamlets, or of great rivers, are clothed with all the majesty of a tropical forest; while an open park-like glade, the chief feature of which appears at the first glance to be the amazing size of its foliage, fills up the higher-lying spaces between the watercourses and the galleries. The number of distinct types of trees, and the variety of forms among the undergrowth, is very great, and exhibits the whole flora of the coast of Guinea, and of the lower-lying countries by the Niger. Trees with large trunks, whose height throws into the shade all the previously seen specimens of the Nile flora, not excluding the palms of Egypt, are here found in serried ranks, without a break, and beneath their shelter the less imposing platforms are arranged in terraces.

In the interior of these virgin forests, leafy corridors, rivalling the temple walls of Egypt, lie veiled in deep perpetual shadow, and are spanned by a triple roof of foliage, rising vault above vault. Seen from without, the galleries appear like an impenetrable wall of the densest leafage, while from within corridors of foliage open out in every direction beneath the columns of the tree stems, and are filled with the murmuring voice of springs and water-courses.

The average height of the roof of leaves measures from seventy-five to ninety feet; but very often these galleries, seen from without, by no means produce the imposing effect which is felt from within in looking up from the depth of the valley or the water-side; because in many places the depression of land or water which makes up the gallery or tunnel-like

GALLERY FOREST IN THE LAND OF THE MONBUTTU.

character of the scene scarcely allows half of the forest to rise above the level ground, many galleries being entirely sunk in the depression. Our illustration gives a view of the gloomy depths of these magnificent forest interiors seen from the height of one of the galleries in a banana plantation; the great tree trunks, thickly overgrown with wild pepper, rise from the depths, and support wide-spreading branches draped with lichens and mosses, above which towers the remarkably fine tree called the elephant's ear (*Platycinum elephantolis*), which grows in rich abundance. High up on the branches are seen the very large nests built by the "tree-termite." Other tree stems, long since dead, serve as supports for the colossal drapery of a liana (*Mucunna urens*), and with their impenetrable festoons form bowers as large as houses, in which perpetual darkness reigns. From the depths of the brushwood gleam the flame-red blossoms of the *cacoucia*, and rivalling with them in splendour are seen the tall shrubs bearing large orange bell flowers of the *spathodea*. The eyes may roam in every direction, and meet with nothing but this unbroken impenetrable greenery. There where the narrow pathways wind along, partly through and partly under the tangle of shrub and bush ascending the valley wall, bare roots of trees form the supports which hold the loose friable earth together. Mouldering trunks, covered with thick mosses, are met with at every step, and make our advance through these waves of massive greenery anything but easy. The air we breathe is no longer that of the free sunlit steppe, or of the cool leafy paths without; it is the heavy, humid atmosphere of our forcing houses, and bears a temperature of from 77° to 87° Fahr. There prevails a constant moisture, produced by the breath of the woods itself, and which it is impossible to escape.

THE BEISA (*Oryx Beisa*). IN THE BACKGROUND, GAZELLES (*Antilope dorcas*).

The negroes belonging to the caravan, while prowling through the backwoods in search of anything eatable, lighted here upon an important discovery; their cry of triumph guided us to the place where they stood clustered together round a tree, very busy with their firebrands. They had discovered in the hollow stem a large quantity of honey, and were preparing to secure their treasure with great indifference to the results of their attack. Honey, wax, and even the little bodies of the honey-makers slain in the combat, were swallowed down by the negroes without any distinction.

The mountainous country of Abyssinia, "the Switzerland of Africa," has many and interesting characteristic forms, and owing to the terrace-like construction of the soil is admirably calculated to shew the vegetation of the different regions. On entering the country from the Red Sea, between 12° and 17° N. lat., we find a compromise between desert and steppe, termed by the Abyssinian, Samhar or Samharu. It is divided, as we learn from the descriptions of Brehm, Krupf, and others, into three districts marked out by nature—the dry, hot lowlands, the moist lands, and the mountain ranges. Shorea bushes grow near the sea, and are bounded towards the interior of the land by meagre saltworts, of grey, colourless appearance. Stunted bushy acacias rise above a chaos of deep-black volcanic hills. Spina Christi, tamarisk, euphorbia, and dogbane are found upon the plain. Gazelles, ostriches, and fowls animate the regions. On the higher hills appear balsam trees (*Balsamodendron*), the primitive form of myrrh, indicating the alliance of this flora with that of the neighbouring country of Arabia. Here graze the herds of the large antelopes. Numerous dog-headed monkeys (*Cynocephalus hamadryas*) and geludas (*Theropithecus* *geluda*) are seen in great numbers, while the trumpet-like voice of the guinea-fowl is heard on every side. Along the watercourses of the moister region extend little galleries covered with *Stapelia*, capers, and the ricinus plant, above which bamboos, tamarinds, and sycamores raise proud crests and giant crowns. Beneath their shadow come the lion, elephant, and rhinoceros to find water. A few miles from the coast the mountain chain rises steeply: deep valleys, worn by the action of water, lead to the heights. In the rocky walls, giant mimosa and the candelabrum, wolf's-milk plant (*Euphorbia colquall*), have taken root, together with the boabab, sycamore, kigelia, tamarind, terebinth, and other noble trees. Countless lianas swing themselves from tree to tree, and, together with an equally endless variety of parasitic plants, often drape the large giants of the forest. Little green parrots build their nests in the dead perforated branches of the colquall, and upon the cliffs the cliff-climber (*oretragus saltatrix*), called sassa by the natives, finds plenty of opportunity for displaying its jumping powers. The whole height of the Mensa and Bogos mountain chains is covered with open forest land of wild olive trees, but the fruit is small and uneatable. In this region we find, together with the European cereals, figs, oranges, peaches, and other fruits grow for the use of the inhabitants. Higher up the mountains there is plenty of meadow land, but little timber, the kousso tree (*Brayera anthelmintica*), the blossoms of which afford a famous remedy for tape-worms, the gibarra tree and shrub-like heather compose the forest. Aloe plants, tree-like thistles (*Echinops giganteus*), and barley fields complete the most interesting vegetation of these plains, more than 9000 feet above sea level. The play of light and colour exceeds all description, the pale-green mimosas and the fresh colour of the euphorbias glisten in tender green, while many large tracts, overgrown with the dark-red blossoms of the aloe, which rise above the pale-yellow leaves, form a splendid contrast of line and colour. The first glance at such a scene teaches us to understand the bright and varied colour of the animal world; if it were differently marked, it would be out of harmony with its surroundings.

Advancing further towards the south, we leave the land of mountain chains and forests, to enter the savannahs, with their tall grasses, the home of the spotted hyena, the tiger-horse, the zebra, and the giraffe (*Camelopardalis giraffe*). The latter, more correctly called *serâfe*, or the graceful ewe, is found from the limits of Sahara to the Orange River.

No other animal in the whole world is so picturesque as the giraffe, seen in its own home; and yet it is very easy to overlook the great misshapen creature, in spite of its height of sixteen or eighteen feet. The hunter is often unconscious of the presence of a whole herd of these animals, unless he examines the scene carefully with his telescope Even the sharp practised eye of the savage is sometimes deceived, and mistakes some weather-beaten tree stem covered with lichen for a giraffe; or, on the other hand, confuses real giraffes with hoary trees. But even this misleading likeness of the animal to its surroundings is not sufficient protection to compensate for its defenceless position when attacked by its enemies. Its swiftness of foot is its only resource; and it is already becoming very scarce, being only seen, as a rule, in small bands. Brehm only saw the stately creatures once, and then only in a company of three, and Stanley only met with one in his travels from the east to the west coast, Schweinfurth speaks of it twice, and in the list of larger game obtained by Speke's East African expedition only one giraffe is mentioned. The pursuit of the giraffe is attended with incredible difficulties and hardships. The hunter must linger for weeks together in the steppes, taking with him excellent horses, camels, and cows; and the Arabs, without whose assistance the undertaking would be entirely fruitless, receive a tolerably high price for the captured animal. The young giraffes yield to their fate without a struggle, but require the most careful treatment to keep them in health. For this reason milch cows are taken with every expedition, so that the giraffe may be at once supplied with proper nourishment. In recent times we have obtained the greatest number of giraffes from Taka, or from the desert lands between the Blue River and the Red Sea. Leaves and branches of the mimosa, and in the south the camel thorn and another kind of mimosa, form their principal food; indeed, it seems as if the well-being of the giraffe depended upon the presence of the mimosa.

The home of the spotted hyena (*Hyæna crocuta*) extends across south and east Africa, to lat. 17° N. or thereabouts; but it is found more frequently in the southern districts than in the northern. Larger and stronger than the striped hyena, it drives out the latter kind wherever they come into contact in the struggle for existence. Its hideous appearance and the horrible likeness of its voice to a human laugh, makes it one of the most dreaded and abhorrent animals of this region. "It is the beast whose shape the sorcerer borrows," say the natives, "when in its nightly rounds he seeks the destruction of the righteous." The spotted hyena, unlike its striped kinsman, is also dangerous to human beings, and often carries away a child, or attacks a weak or fallen traveller.

Hildebrandt has written a description of the bird world of the country between Kilima-Ndscharo and the snow mountain Kénia. "The forest re-echoes," he says, "with the wedding march or tender love song of the birds. The song of the so-called African kolibris, the brilliant nectariniæ, called by the Wakamba *Tsetvétseve*, in imitation of their twittering cry, and the rather larger kinds of showy finches and bush singers are, so to say, the children's voices of the quire. Pirole and shrike respond in long-drawn flute-like notes, while a certain variety of the latter bird (*Laniarus lugubris*) perform a duet, the female bird running down an octave, as if on the highest register of a piano, whereupon the male answers with a high piping note from the nearest bush. The starling, with its beautiful plumage, steel blue, green, and violet, glittering bright in the sunlight, is one of the best singers of Africa; but the crown belongs to a throstle, the prima donna of the bird artists. The lively concert of the weaver-birds, which have built up their nest village in the trees of the Wakamba, blends with the shrill chirp of the African sparrow (*Passer Swainsonii*), a bird in no way behind its European kindred in impudence. Far away in the dense forests is heard the loud laughter of the woodpecker, prophet of good or evil, war or peace, to the Wakamba, according as it is heard to the right, or in front, or at the back of the traveller. These birds are hated neighbours, and in order to drive them from the villages, earthen pots are hung upon the trees. A wattle bird (*trachyphonus*) is the object of a still deeper and most exaggerated dread; this bird is said to kill the cattle from whose backs it picks their parasitic insects. Another companion of the caravan is the alarm bird (*Schizorhis leucogaster*), called by the Waswaheli, *Gnoa*, or *forward*, from its peculiar cry, which resembles the word. Very often the weary traveller pulls himself together to follow the encouraging cry of the gnoa. The hooded owl is considered throughout Africa, as it is in many places among ourselves, to be the bird of death. A solitary plaint is uttered by the turtle dove (*Turtur senegalensis*); a shrill wild cry by the falcon, when in the grey morning it surveys its hunting grounds from the tall, bare adansonia. The voice of the rhinoceros-bird is in keeping with its old-fashioned looks, is guiltless of all modern operatic trills and quablings, and comes forth from its overgrown bill in a hoarse barking croak. Other and purely African tones are the ear-splitting cry of the guinea-fowl and the francoline, when they are heard by the water at night, or when the former chooses its night quarters in the trees. But one day I heard the voice of a bird which I could not forget for a long time; it imitated to perfection the grating of an unoiled wheelbarrow, and awoke within me a feeling which I once experienced in Arabia, where, on the 'burning rocky strand,' I found a lovely and sorrowing head of cabbage, and I shame to say it, gave myself up to a fit of home sickness. Real singing birds are scarce, although the bird world is numerously tenanted; but it would be ungallant to lend too ready credence to the often-repeated saying, that 'in Africa, birds have no singing voice, flowers no fragrance, and women neither mind nor heart.'"

One of the arms of the Delta through which the Zambesi pours its waters into the sea is the Kongone. A richly coloured picture unfolds itself before the eyes of the explorer who attempts to travel by it into the interior of the country. The first twenty miles are shut in between marshy lands and mangrove trees, the latter often draped in valuable lichens, which, however, do not seem to be gathered. Giant ferns, shrub-like palm trees blended here and there with the wild date palm, are seen throughout the forest, but the greatest number of trees found in them are the mangrove tree, or rhizophora. These true amphibious plants do not love to be fettered to the earth, but throw out wide-spreading roots into the bed of the river, and not content with this, send down from their wide-spread branches aerial roots like strong ropes, which strike root as soon as they touch the ground, providing the parent stem with fresh support and nourishment, but making the tangle of roots by the shore utterly impenetrable. The clusters of their pale yellow fruit contrast pleasantly with the bright green leaves, but are not good to eat. In many places patches of milola, a shadowy *hibiscus*, with large pale yellow blossoms, cover the shore. Rope is made from the bark of this plant, and it is principally used for the lines to which the harpoons are fastened; harpooning being the favourite method of the natives for capturing the hippopotamus. As we advance, screwpines (*pandanus*) become visible, and on passing from the Congone into the Zambesi we find some of them as high as church steeples, and Livingstone tells us of the remark made by an old sailor who said that to finish off the picture "there only wanted a grog shop by the church." Further on, the lemon trees begin to be visible. The sombre woods re-echo to the joyous, merry song of the kingfisher (*Halcyon striolata*). As the steamer ploughs through the winding river bed, a pretty little heron or brilliant kingfisher rises with a cry of terror from the river bank, flies before us for a short distance, and settles quietly down to be scared away again in a little time. The beautiful fish hawk (*halietus vocifer*) sits on the crest of a mangrove tree (*rhizophorus*), to digest his breakfast of raw fish: he has made up his mind not to stir, and it is only when we are close upon him that he spreads his wide wings and takes to flight. The brilliant ibis, with its keen sense of hearing, catches the unaccustomed sound from afar, and springing up from the mud, where it is enjoying a quiet family dinner, is far away before the danger approaches, uttering a loud hoarsely contemptuous ha! ha! ha! as it flies. The rhizophora are now behind us, and in their place stretch wide levels of rich black earth, covered with giant grasses, which rise above the hunter's head, and so make the chase impossible. When the grass withers, it is set on fire, and the conflagration prevents any great abundance of trees from being grown; for only a few varieties, such as a fan palm (*borassus*), is able to escape the sea of fire which rages every year across the grassy plains. Between the bananas and cocoa palms on the right bank of the river appear several of the native huts; they stand only a few feet above the moist ground, and are built on piles, and entered by means of ladders. The soil is very fertile, and the gardens are really excellent. Rice is grown in great abundance; batatas, gourds, tomato, kohl, onions, peas, and a little cotton and sugar-cane were obtained. It is said that in the course of a few years the potatoes lose their taste, and assume the flavour of frost-bitten potatoes and batatas (*Convolvulus batata*).

The year is divided here into three seasons—a cold, hot, rainy season. The cold season lasts from May to August; the hot season runs through August, September, and October; and the rain takes up the remaining part of the year. The rainy season is peculiar in this district; in an average year, when the crops turn out well, the rainfall amounts to about thirty-nine inches. On many days it does not rain at all, and seldom the whole day; on others there is only a passing shower, preceded and followed by hot sunshine; sometimes there is an interval of eight or fourteen days without a drop of rain, and then the fruits of the field suffer.

At the end of the hot season everything is dry and dusty; the air is very sultry, and filled with a blue mist. The whole appearance of the country improves rapidly as soon as the rain begins. Although the atmosphere is not moist, like the air of a forcing house, as it is in many other places, yet the brown parched hills and vales are quickly covered with fresh green. The air is gradually freed from the smoky vapour, and the distances are clearly defined. The scenery lies bathed in a sea of light; and in the morning, before the glow of noontide has dazzled the sight, everything looks deliciously fresh and cool. When Livingstone asked one of the Bechuanas what he understood by the word "*boitsepho*," or holiness, the answer was, "When the rain falls during the night, and washes the whole earth, and the leaves and every living thing, and the rising sun shews a dewdrop on every leaf, and a fresh breath of wind stirs the air, *that* is holiness." The young leaf of several trees, especially in the highlands, comes out orange and pale red, as with us in the autumn; and as the leaves grow larger, the colours change into a fresh, vivid green. Brilliant white, scarlet, pink, and yellow blossoms are found everywhere; and here and there the dark-red of the kigelias lend a special charm to the scene. Many trees like the scarlet-blossomed *erythrina* attract the eye by their vivid glow of colour. The white, full blooms of the breadfruit tree, which sometimes comes before the rain, and the charming little flowers of other trees clustered in rich groves, adorn the forest scenery. Myriads of wild bees are busy from morning to night. Many acacias have a special power of attraction for a kind of beetle, while the palm entices another kind to collect within its roomy leaves. Insects of every kind appear in full force; brilliant butterflies flit from tree to tree, and never seem to tire. Armies of ants are busy collecting their food, and carrying it homeward in triumphal procession. Winter birds of passage, as the yellow wagtail and the blue shrike (*dicrurus*), are gone away, and other species have arrived. The brown Milan hawk, the speckled cuckoo, the almond crow, and the rhinoceros-bird, mingle their shrill pipings and loud cries, which are happily lost in a concert of sweeter music poured from the throat of many a warbling bird, until the African Christmas is as vocal as an English May. Many birds of the weaver kind have already laid aside their winter dress of dark brown, and donned a summer costume of scarlet and coal-black; others have doffed their green plumage, and appear in a pale yellow spotted with velvety black. The pretty little male widow-bird, with the pale-red beak, has put on his black and white suit, and displays his long and graceful ornamental feathers. A goatsucker (*cosmetornis vexillarius*), only ten inches long from head to tail, appears in November, with two beautiful feathers, twenty-six inches long, in the middle of each wing. They give a slow undulating motion to the pinions, and obviously retard their flight; why this effect is produced is unknown, but it is certainly the case, for at other times he flies very fast, while in November a child can hit him with a stone. The natives can knock down a hare with a throw of a club, and they are excellent marksmen; but none of them could hit a goatsucker in its ordinary dress, although it perches in the twilight right before their feet. Singing birds are not restricted to the villages, although it has been noticed that they generally assemble in their neighbourhood. Fabulous numbers of aquatic birds of many kinds haunt the swamps of the Schire. Troops of the *plotus*, a bird of the pelican tribe, and the cormorant (*graculus carbo*), stretch out their snake-like necks in wonder, and fly away, or plunge into the water. The heron (*ardea bubuleus*) hovers aloft in large flocks, and wends its flight right across the green land, often shewing by its presence where to find buffaloes and elephants, on whose backs it delights to perch. Pelicans, ducks, geese, and hundreds of the noisy bird, *Anastomus lamelligerus*, are started from their quiet resting places. With dignified earnestness the marabout slowly stalks along the shore. Towards night flights of scissorbills (*rhyncops*) appear in search of food, skimming the water with the lower part of the bill, which is nearly half an inch longer than the upper part. At the northern end of the marshes, and a few miles from the river, begins a great wood of deleb palms (*borassus flabelliformis*), which extends for several miles. The grey trunks and green crests of this great mass of trees gives a pleasant tone to the colouring of the scenery. The deleb, a fan palm, is a very useful tree. The fibrous flesh round the large nut has a pleasant taste, and is eaten by men and elephants. The natives bury the nuts until the kernels begin to germinate. When they are dug out and broken, the inside tastes like a potato, and is highly valued in times of scarcity as nutritious food. During several months of the year, palm wine or *sura* is obtained in large quantities. When fresh, it is an agreeable beverage, something like champagne, and does not affect the head; but if it has stood for an hour or two, it is extremely intoxicating. Incisions are made in the hard outer bark of the tree, and

ELEPHANTS, ZEBRAS, AND GOATS (*Elephas Africanus, Equus Zebra, Cobus Elipsiprymnus.*

stakes are driven into the soft hollow interior to make a ladder; the point of the spathe is cut off, and the sap flowing from the fresh wound is collected in an earthen pot hung up for the purpose. As often as the native climbs up to empty the pot, he strips off a thin layer from the wound, so that the sap may flow on unchecked. In the forest temporary huts are erected near the trees, and men, women, and children remain day and night by their respective trees, living on nuts, fish, and wine.

The nearer Livingstone approached to Lake Nyassa, the more abundant did he find the larger kinds of game. As a sample of what one may expect to meet with in districts where there are no human dwellings, and where firearms are unknown, we may mention what we ourselves saw. On the morning of the 3rd of July a herd of elephants passed by our sleeping place. We rose, and came upon a large number of guinea-fowl; fired at one or two, bringing down as many as were likely to be wanted for our mid-day meal, or for to-morrow's breakfast, and left them lying in the road, to be picked up by our cook and his assistant, who were following us. As we proceeded farther, francolin fowl ran right across the road before us, and hundreds of turtle doves rose up with loud cooings, and flew away. Besides these birds, wild ducks and geese were counted among the list of bird game. At sunrise a crowd of palas (*antilope melampus*), larger than our European fallow-deer, standing still in our path as we advanced in single file, allowed the first man of our column to come within fifty paces; and as we were provided with meat we let them trot away unmolested. Soon afterwards we came upon a herd of wild goats (*Cobus elipsiprymnus*), which are here much darker in colour and drier of flesh than the same kind near the sea coast. They looked at us, and we looked at them. We went on, and fell in with a troop of female koodoos (*Strepsiceros kudu*), accompanied by one or two magnificent male koodoos,

HYENA DOGS (*Hyæna pictus*) PURSUING A SABLE ANTELOPE (*Onyx iacotryx*).

with great branching horns; they hastened away from us toward the parched hillside. We have left off shooting antelopes, because our people have been so gorged with meat that they have become dainty. They say they do not want any more game—it is dry and has no taste—and ask us why we do not give them any shot to shoot the guinea-fowl, which they like better. At eight o'clock the tsetse begins to buzz round us. Just as we are thinking of our breakfast, we come up with a few buffaloes (*bos caffer*), grazing by the roadside; but as soon as they see any human beings approaching, they take themselves off at a heavy gallop. We fire, and the foremost beast, badly wounded, leaves the herd, and we see it standing still between the trees; but as it is a dangerous thing to follow a wounded buffalo, we keep on our way. It is this losing of the wounded that makes firearms so destructive for those animals. After breakfast we went to a pool of water; by the side of the pool stand two elephants, and at a respectful distance behind those monarchs of the wilderness are a crowd of zebras and wild goats. As soon as they are aware of our approach the elephants beat a retreat, but the zebras stay till the first man is within ten paces of them, and then gracefully gallop away. Upon the plains extending between us and the river, and covered with short grass, antelopes of different kinds are quietly grazing or lying down to rest. Wild pigs abound, and walk about in the open during the day, but they are so shy that they seldom allow us to come near them. Directly they feel alarmed, they erect their thin tails stiffly in the air, and trot off at full speed in a straight line. A troop of monkeys playing at the outskirts of the wood disappeared into its deepest recesses as soon as the singing of our people reached their ears. The nights are warmer now, and filled with almost as much novelty and interest as the days. A new world awakes and comes to the fore, and if we may judge by the noise they make, a much more populous world than that which takes its walks abroad in the daytime. Lions and hyenas roar and growl round us, sometimes coming unpleasantly near us, although they never ventured in our midst. Unknown birds sing their prettiest melodies, while others shriek and cry as if in fear or anger. Wonderful insect voices meet our ears; one of the natives tells us that they come from a large beetle. Reptiles, although present in great numbers, seldom molested us. Scorpions and the venomous snakes belonging to their tribe must not be forgotten. To complete the general survey of the animal life belonging to this district, we must add the hippopotamus, the zebra (*equus zebra*), the tiger-horse (*equus burchelli*), the hyena-dog (*lycaon pictus*), and the crocodile.

This account of the abundance of game might suggest the repetition of a few sensational adventures, with the usual accompaniments of hair-breadth escapes and impossible situations; such stories as those which appear to be becoming the fashion in many recent books of African travel seldom bear the impress of truth, and the mere recital of the indiscriminate slaughter of inoffensive animals is too repulsive to deserve being repeated.

Although there are no forests, properly so called, to be found in Natal, yet, in spite of the absence of tall trees, there is no lack of valuable and useful wood. Most of the trees are covered in spring with a fine display of bright-coloured blossoms, and some are in flower all the year through. A centaury (*Erythrina*), known in the colony by the name of Kaffir tree, unfolds its bright scarlet bloom in the midst of winter. There is the fustic (*Taxus elongata*), sneezewort hellebore (*Pteroxylon utile*), an evergreen, the wood of which, when fresh, exerts an irritating influence on the olfactory nerves, such as is possessed by snuff or pepper; the bean trefoil (*Laurus bullata*), which gives out an unpleasant smell when manufactured; ironwood, ebony, and many other less familiar kinds.

Towards the end of September, when the dry season is coming to an end, the long absence of rain and the parching sunbeams clothe the landscape in a vesture of brown, and the time is at hand when the Kaffirs and European settlers set fire to large tracts of land. It is a wild, fantastic sight, as the wall of fire rises up from the valleys, swaying hither and thither at the will of the wind, winding in tongues of flame up the mountain-side, and lighting up the night with its weird brightness. The plains, blackened and consumed by the fires, stretch out for miles their ash-covered levels, black as a funereal pall. No life is left upon them, and nothing is seen but here and there the bodies of numberless charred locusts. But the gloomy sight does not last long; at the first heavy shower the fertilizing ashes give birth to the richest and most varied plant life, entrancing the senses with its sweet fragrance and variety of forms. Countless bulbous plants shoot up with incredible speed in a beautiful confusion of growth and colour; the bright scarlet, which is their prevalent colour, shining through the green grass. They are principally liliaceous plants, amaryllis, and gladiolus, whose beauty delights the traveller. He soon finds that even the colouring of a landscape is sufficient to produce a great effect upon the mood of the observer; for when Mohr, on his way to the Victoria Falls of the Zambesi, wandered for weeks together in September, 1866, through the blackened, desolate scenery of Zululand, where all vegetable and animal life seemed to have died out as in the desert itself, he found that a discontented, melancholy humour took possession of all the caravan, both native and European; but scarcely had the life-bringing rain transformed, as by the spell of the magician's wand, the thirsty plain into a laughing flower garden, than the mad merriment of his Kaffir escort broke out again into the gayest good humour, and even the civilized Europeans felt the influence of the joyous re-awakening of the beautiful plant life. Among the flowers which then come into bloom, one of the most admired is the *Amaryllis belladonna*, known by the name of the Natal lily, of which the enormous bell-shaped blossoms delight the eye with their white and lilac blooms, the slender stem rising more than a yard above the earth.

As to the fauna of Natal, the rival monarchs of the African forest, the lion and the elephant, have long since disappeared from the country. On the other hand, the smaller antelopes are all found haunting every unfrequented copse and thicket throughout the colony, especially the graceful so-called little ibex (*Tragulus rupestris*), and in rocky solitudes the *Orlotragus saltatrix*. The leopard is still found in great numbers, and does incalculable mischief among the flocks, breaking into their inclosures by night. The large, magnificent antelopes of the continent are also found here, as, for instance, the eland (*Kanna, bucephalus oreas*), the beautiful stag-like koodoo (*Strepsiceros capensis*), the wild goat (*Eleotragus*), and many others. The bird world is represented by the most numerous and brilliantly feathered specimens; it is especially numerous in the bush woods of the well-watered districts of Zululand and Natal; but the great unique bird type of Africa, the ostrich, is only seen here in single specimens, which have been brought across the mountains, and tamed. There are several kinds of vultures, three of bustards, while among the birds distinguished for their brilliantly coloured plumage are the red weaver-bird (*Pyromelana oryx*), the paradise widow-bird (*Vidua regia*), two kinds of lories (*Corythaix persa*), one blue and one green, glittering in metallic hues, and wearing a beautiful crest. Next to these rank the guinea-fowl, the francoline, a large spurred partridge, something like a pheasant, a smaller yellow partridge, the bright-coloured sand-grouse (*Pterolles variegatus*), the speckled snipe (*Rhynchea capensis*), several kinds of wild doves, the red honeysucker (*Cinnyris gutturalis*), and the wonderful honey-cuckoo (*Cuculus indicator*), which leads the traveller to the place where honey is to be found. Lonely lakes and tarns serve as the resting place for different kinds of water birds, ducks, and geese with spurs attached to their pinions.

Even the world of insects is full of endless variety and interest, although the butterflies of Natal cannot compete either in brilliance of colour or variety of form with those of many other places. The wonderful mantis, and a so-called "flying leaf," excite our wonder by their grotesque forms; but the uninitiated traveller, who looks about him only by day, and does not bring to his observations the practised eye of the naturalist, bestows no attention on these creatures, mistaking them for the withered leaf or dry twig, which the power of mimicry, by which they support and protect their defenceless existence, enables them to represent. The termites, which are distributed throughout the whole of Africa, are truly the pests of the country. Their nests, built of torn pieces of straw, sand, and clay, firmly kneaded together, are used occasionally by the colonists for manuring the fields and building walls. But the most horrible creature in the insect world is the so-called *tick*, found in the bushes of the coast district of Natal. No horse or ox is free from this plague, which is scarcely as large as a pin's head when it attacks its victim, but hangs upon it like a bluish grey sack as large as a pea when it has satisfied its thirst for blood. It will even sometimes attack human beings, especially children. The number of snakes is countless; by far the greater number are not poisonous; and yet, considering how numerous these reptiles are, it is very wonderful that so little harm is done by them. First among their number is the cobra (*aspis haje*), found throughout the whole of eastern Africa, and wearing a different garb in different places. In Egypt it appears as the straw-coloured, spectacle snake, while it is found here in a grey and sometimes in a black dress, and is known in Natal by the name *Mhamba*. It sometimes reaches the length of eight feet; coming out at night as a rule, but sometimes seen by day in the rainy season, when it creeps out of its hole to warm itself in the sun, and lies coiled up in the grass. The cobra is more dreaded than any other snake in the south-east of Africa. Riders who have approached it suddenly and by accident are often pursued for miles by the deadly reptile. Much more numerous than the cobra, and equally venomous, is the puff-adder (*echidna arietans*), but it is not nearly so much dreaded as the cobra, because it is much more helpless and slower, and is therefore more easily killed. The puff-adder likes to frequent the neighbourhood of houses, especially if there are any rats or mice to be found in them. In Matebele land, near Natal, there is also a brown and black ringed cobra. The giant snake, python, is not poisonous. It is found here in two varieties, and reaches the length of from fifteen to eighteen feet. Mohr relates that these snakes were actually bred and encouraged in certain sugar plantations, where they lay quietly ensconced in the furrows of the field, wholly indifferent to the presence of men, and performing the duties of our domestic cat, killing great numbers of rats and mice, which multiply to such an extent in the plantations as sometimes to endanger the crops. Besides many other kinds of animals, we find still in the Transvaal, lions, hyenas, jackals, buffaloes, gnus, zebras, hippopotami, rhinoceroses, and other animals eagerly pursued by European sportsmen; and last and least, the dreaded tsetse fly.

The cultivation of Natal and the Transvaal presents little worthy of note; in sailing along the coast, the eye is attracted by mountain scenery covered with dense woods, and by peaceful valleys overshadowed by rich verdure. Here and there are seen the native villages with their beehive-shaped huts; merry Kaffir lads tend the large flocks and herds upon the plains; hard-working women are busy at work in the fields of maize and durrah, or carrying on their heads large bundles of fuel into the village, while the men lie idling away the time at the entrance of the huts. Beyond the village stretch long miles of open country, where the peaceful and fertile plains shew no sign of human activity, until the time comes when the valleys will be awakened with the joyous shouts of merry labourers working upon the hundred thousand acres of the most productive land in the world.

A farm is rarely seen. If it is situated near the coast, it yields, besides the produce of tropical lands, coffee, sugar, pisang, pineapples, maize, batatas, potatoes, durrah, corn, oats, and European vegetables. The domestic animals are oxen, horses, pigs, and goats. On the hills, up to the height of about three thousand feet, vegetables, corn, maize, oats, horses, and oxen are found; while between three and four thousand feet, sheep-breeding is carried on with the greatest success. In the interior of the country, sheep and cattle-rearing form the chief revenues of the farmer; a kind of friendship grows up between man and beast, and even the Kaffirs sing, in touching songs, the praises of the sleek, lowing kine. Sometimes the men prolong their hunting expeditions into the bush for months together, which is not surprising, if we remember that the farm is entirely cut off from any connection with the coast, and that its produce can only be brought to market by means of a gigantic waggon harnessed with fourteen or even thirty oxen.

South Africa.

The Transvaal and Natal, whose flora and fauna we have described in our last chapter, belong in a geographical and zöological point of view to South Africa; but their flora is purely tropical, and is classed with that of Central Africa. Heat and moisture combine to call forth a plant life which forms a vivid contrast to that of the Cape and of Calahari. It is true that the two latter places have an equal amount of warmth; but the absence of the life-giving rains of Natal make Kalahari almost a desert; and the Cape, although it is not uninhabitable, is yet useless for any extensive agricultural operations.

The Cape is divided into three terraces, separated one from the other by mountain frontiers, and connected by clefts and gorge-like ravines. The lowest terrace comprises the narrow strip of coast-land, and has an average height of from 300 to 400 feet above the sea level; while the other terraces, the *Karroo* or high plateau, and the Roggefeld, have an average height of 2,050 and 3,900 feet. Each of these terraces has its own characteristic form of vegetation, depending less upon the amount of heat than upon the rainfall, and its distribution throughout the year. Even Capetown itself, notwithstanding its coast climate, has a yearly temperature of 62° Fahr., so that the best wines succeed there; but its yearly rainfall is only twenty-four inches, although the town is situated in one of the moistest districts of South Africa. The sea winds which bring the rain empty themselves of the greatest quantity of their moisture upon the mountain slopes over which they pass, thus diminishing more and more the rainfall in the interior of the country; for instance, in the eastern part of the Karroo the rainfall is only about 13½ inches throughout the year, and on the Gariep it is so slight as to be almost nil, so that the river is lost amid the sand of its mouths. Not that the rain is always withheld; on the contrary, it sometimes descends with such violence that the Gariep suddenly rises in the deep channels which it has washed out for itself to the height of from thirty to thirty-six feet. Even the moisture in the air, which in Capetown holds an average of seventy-two per cent. of the whole amount obtained when saturated, is very slight upon the highland plains. On the Karroo, when the first drops of a heavy shower began to fall, it was only twenty-nine per cent., little more than may be observed in the Sahara.

A comparison of the scenery of the Cape after a rainy season, and the longer or

POLAR BEAR AND WALRUS.

shorter periods of vegetation dependent upon it, leads to the following results. The winter rains of Cape Town extend from the month of May to September, during which period more than two-thirds of the yearly rainfall descends. Most of the plants bloom in July and August. In June and July appear first the bulbous plants, following very soon upon the first rain, and springing up as if by magic, to change the scene into a garden of bright-coloured flowers; then come the shrubs, and last of all the succulent plants. The later seasons of the year are not, however, entirely destitute of blossoms; the cessation of growth does not extend to every species, because in the neighbourhood of the coast the soil is never so thoroughly dry as on the plateaus. The Table Mountain, which rises directly above the town, and stands in close proximity to this winter garden of the Cape flora, presents an entirely different aspect. The south-east trade-wind, which is a dry wind from the west coast, wraps it round, chiefly during the summer, in its bank of clouds. Upon its height the months of February and March display a number of rare flowers, beautiful bulbous plants, heaths, the long-lived, brightly coloured immortals (*Helichrysum*), at a time when even before the end of the spring, about November or the beginning of December, the vegetation of the plain is parched and dead. On the hills and mountain chains which separate the western coast terrace from the Karroo the period of vegetation is prolonged or delayed; the plants are in full bloom in spring, and in the months of September and October. On the Karroo itself the period of vegetation is very short, so that the wide plains are uninhabited, and only fitted for cattle rearing. The scorching heat of the summer is decisive for the vegetation, and is by no means atoned for by the frequent thunderstorms in summer. A few showers of rain in winter suffice to awaken the vital forces of the plants from their long sleep; but the Karroo's time of blossoming scarcely lasts for a month, and toward the end of September it is once more a barren wilderness. And even this short fertilising winter rainfall is withheld from the upper terrace of the Roggefeld, where only swift passing clouds discharge now and then their contents as if by accident. The eastern division of the Cape flora corresponds with its own rainy seasons; and it was in the months of December and January that Duèze collected his specimens from Caffraria and Algoa Bay.

In every place, vegetation is roused from its torpor by the downfall of rain, and checked by the re-appearance of drought. It is only in certain trees brought from Europe, such as the oak, that the winter sleep and the cold season coincide in point of time, while their bursting into leaf accords with the season of the southern hemisphere.

Kalahàri stretches northward from Gariep at an average elevation of 3,750 feet above the sea level. Its geological conditions, and especially the composition of the earth's crust, cause it to differ widely from the Roggefeld, and to be classed as a separate region of vegetation. The Roggefeld, situated only 150 feet below, rests upon a substratum of ferruginous red sandstone, which forms only a slight crust of earth, and this is the principal reason why the grasses and the acacias, which like a limy and sandy soil, are not seen beyond the Gariep and why the vegetation of the Gariep consists almost exclusively of shrub and bush. The conditions of temperature at Kalahari are so much like those of the Sahara, that we are scarcely prepared for the great difference between these tropical deserts, as to the amount of moisture they receive, and the time when it principally falls. In Kalahari the summer brings frequent thunderstorms and a consequent development of plant life, in Sahara the few tempests occur in winter, and create a scanty vegetation. Kalahari is never entirely without rain, except upon the coast, where the loose drifting sandhills and bare rocks recall the scenery of the desert, and only admit of an extremely poor vegetation, consisting of stunted grasses and grey, greenish bush.

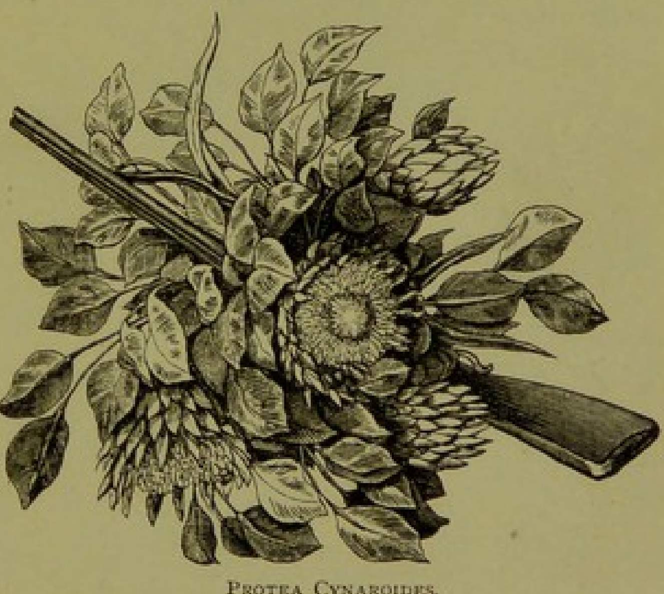
In no other country is it so difficult to deduce the character of the flora from the physical conditions of vegetation as in the Cape. Both soil and climate are unfavourable to plant life; the landscape appears even more parched than we should expect from the meteorological conditions, but the variety of plant forms found in conditions of vegetation so monotonous and so unfavourable is greater than in any other part of the world. The number of vascular plants as yet known to belong to the Cape flora exceeds probably 8,000, while the German Empire, which is larger by one half than the Cape, has only 2,258.

And we must remember that Germany has been subjected to such close botanical research that it is hardly possible to discover any new kinds, while the Cape doubtless possesses many plants which have escaped the collector's observations. First of all, there are a number of Cape plants which only grow in one place, as if they were living upon some ocean island. The silver tree (*Leucodendron argenteum*) and several other proteaceæ, are found nowhere but in the little promontory of the Table Mountain: none of the proteaceæ growing on the neighbouring Hottentot-Dutch Mountain are seen among them, and the heights of Stellenbosch and Drakenstein, which are directly connected with the Table Mountain, have their own individual types. And in many years a large number of plants, especially bulbous forms, do not flower at all, because no rain falls in the short time when they ought to blossom.

Every difference of level and soil, hard clay, gravel, and loose sand, produces in the Cape its own special sword lilies. They often appear in vivid, brilliant colouring, scarlet, pink, gold, and orange, and no less beautiful are the variegated flowers of the land orchids (*disa, disperis*, etc.), which grow between the shrubs. No country in the world has furnished Europe with so many ornamental plants, especially since the beginning of the present century; so that at one time the forcing houses which needed no heat were called Cape houses. There are still rich collections of succulent plants (stapelias, euphorbias, aloes, mesembryanthemums), but like many of the heaths and other plants which once filled our conservatories, and are now lost to culture, the sword lilies and other liliaceous plants have died out to a still greater extent, because it is so difficult to supply their necessary conditions of existence by artificial means. It is comparatively easy to prepare the same kind of soil, and to avoid too much watering; but not so easy to keep the air dry enough to suit the atmospheric organs of the Cape plants.

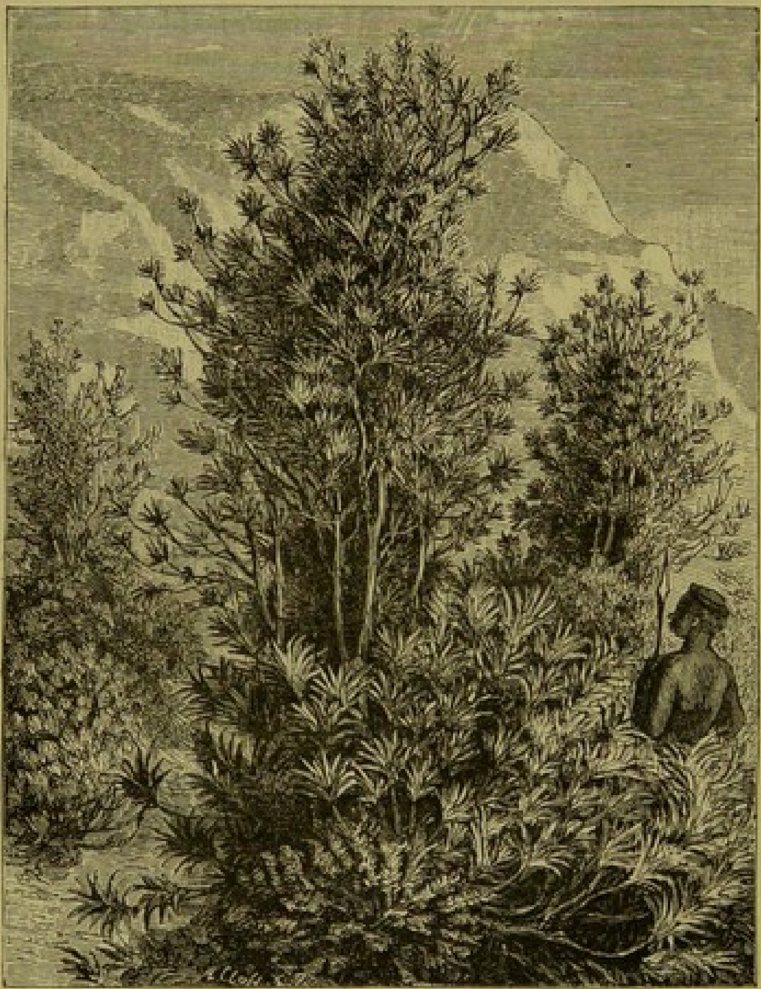
The Cape is poor in trees. Forests are almost exclusively found on the south coast, between the Cape and Algoa Bay; for the trees are forced to retreat from the piercing rays of the sun to the narrow mountain passes or the watercourses, as they cannot obtain sufficient moisture on the plains. Except in places where the industrious farmer has improved the soil by careful irrigation, the plain is almost without a single tree or even a shrub; and the luxuriant weeping willows (*Salix gariepiensis*) and the fruit trees, which betray the presence of a farm even from a considerable distance, die as soon as the settler removes and leaves them to themselves, a sure sign that the climate of the plains is unfavourable to tree growth. The trees which are most generally seen belong generally to the olive and laurel tribe, with the exception of some succulent plants to be mentioned later, as the olive and bean trefoil (*Olea verrucosa* and *Laurus bullata*), some with feathery leaves like the tamarind, and a few coniferæ, which have no needles, but resemble the cypress (*Widdringtonia*) or the olive (*Podocarpus*). The trees are seldom more than eighteen or twenty feet high, but the wood is sound, and the stems disproportionately thick. In Finysa Forest yellow wood (*Podocarpus thunbergii*) is found too large to be spanned by four men. The palm tribe is only represented by a dwarf date palm (*Phœnix reclinata*); in their stead we find the singular cone-bearing palms, or cycadaceæ. The stems, generally three to six feet high, appear scarred by the marks of the fallen leaves, and often contain an edible pith; for instance, the *Encephalartos cafer* yields the so-called caffer bread. Above the stem waves a rosette of feathery leaves, set with thorns, as in the *Zamia horrida*.

The shrub family contains numerous and characteristic representatives. They are on an average from three to four feet high, and resemble each other so closely in their simple formation of leaf, that not until they come out into flower do we recognize how lavish Nature has been in her adornment of the insignificant-looking plants. A proof of the poverty of tree growth on this soil, where the meagre brushwood yields little leaf mould, and the friable sandstone is incapable of retaining the moisture, is shown by the fact that the heavy waggons of the colonists, drawn by their long teams of oxen, are able to proceed unchecked in every direction from Cape Town to Caffraria, and even farther still. The eye is seldom met by any pleasant picture. The foliage is generally small leaved, blue grey in colour, and too scanty to cover the boughs, so that the lovely fresh green of our own landscape scenery is never seen here, and the absence of this charm is not atoned for by the beautiful silver tree, which shines like silver in the sunshine. The majority of the shrubs are heaths and proteaceæ, with 400 and 250 species respectively. The delicate blossoms of the former are more beautiful than those of our European heaths, and the proteaceæ delight the eye with their giant blossoms, which have the fragrance of honey. Here and there a wonderful flower is seen, the *Protea cynaroides*, of a tender red colour, the petals covered with white silvery down. Each flower grows singly on a low stem, and attracts the attention by its remarkable size, often measuring ten inches in diameter. Many of the shrubs are protected by thorns or hairy covering from the rays of the sun. The silvery gleam of the proteids, which has inspired some of the earlier travellers with their wonderful stories of silver forests, is only the silky down which covers the leaves. Along the rivers in the interior of the country the banks are generally fringed by the Karroo thorn (*Acacia horrida*), known by its long ivory-white thorns. It is almost the only representative of the mimosa tribe south of the Gariep, for it is only in the Kalahari district that the thorny plants and mimosas are found in great variety. In this district the thorn bushes present a serious obstacle to free movement. There is one kind of acacia armed with a double set of thorns, which are so arranged that in trying to get free from the crooked, hook-shaped thorns, one is forced to touch the others, which are as thin and as sharp as needles, two inches long, and capable of giving considerable pain. The hook and needle grow side by side in pairs upon this formidable plant. But the most noticeable of all is the "wait-a-bit" thorn (*Wacht een beetjen Doorn*), or acacia detinens. It has received its colonial name from the short hooked thorns, which are bent in two opposite directions, and from which it is very difficult to extricate one's self.



PROTEA CYNAROIDES.

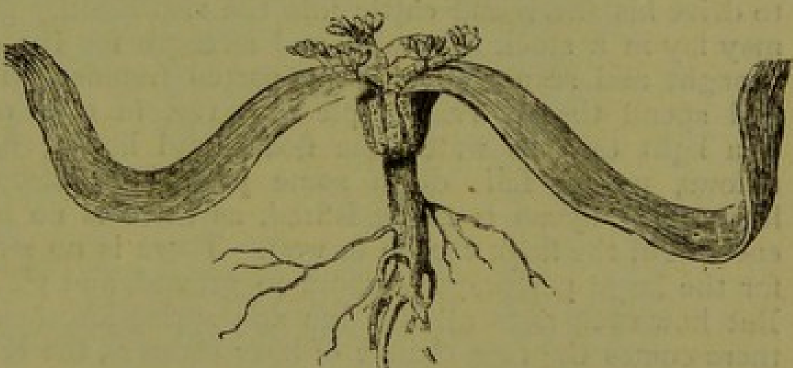
As the track gradually became less and less distinct, and the wait-a-bit thorns surrounded us more closely, our desperate tussle with this exasperating foe would have presented a comic spectacle if there had been any spectators. The thick hide of the oxen felt the ungentle touch as keenly as our limbs, through their covering of clothes. Nothing was strong enough to prevent the thorns from piercing it, and whatever they had once seized upon could only be released in tattered fragments. It was amusing to see how the oxen tried to avoid the touch, setting off at last in a mad gallop over the lower shrub, a freak which by no means improved the waggon, and every five minutes a halt was necessary to right it again. No sooner had we resumed our journey, and succeeded in gaining a wide berth to one formidable bush, than the oxen would come to a standstill before another which had been hidden behind it. Quickly the driver turned to punish them for their delay, when "wait-a-bit" was mutely called to him from behind, and the lash was intercepted in its downward course. In great wrath the man attempted to get it free from the tormenting hooks, but was speedily admonished to calmness and patience by a strong bush in the rear, which plunged its thorns deep into his trousers. In this way we strove to battle through, not without strange caperings and some little bloodshed, until the increasing darkness made the struggle too unequal, and we were obliged to unyoke the bullocks and camp out, still closed round by the formidable ranks of the thorn bushes. (Fritsch.)


PROTEACEÆ.

When Burchell attempted to examine the thorn, he was warned by the natives, and approached it with great caution. But he was not able to prevent a little twig from catching his sleeve; and in trying very cautiously to release himself his other arm was caught; and he soon found himself completely helpless, like a fly entangled in a spider's net, and could only be extricated with great difficulty by the aid of others.

The most beautiful tree in Kalahari is an acacia armed with thorns from two to three and a half inches in length, the giraffe acacia (*Acacia giraffæ*), called by Livingstone the camel thorn. The tree is from eighteen to thirty-six feet high, and thrives well on a dry sandy soil; it is eaten by the animal whose name it bears. Among the few remaining tree forms of Kalahari, we have yet to mention an olive (*Olea verrucosa*) and the mopane tree, whose dark-green twin leaves curl their edges upward toward the sun, recalling the shadowless woods of Australia. And just such a wood, open and hot as it is, was welcomed by Anderson with delight, as an unexpected relief from the hardships of the day, because he saw there, for the first time in the desolate Kalahari region, beautiful leafy crowns and thornless stems. Even the indifferent expression of countenance of his native companion lost something of its ordinary dull insensibility, and displayed pleasure at the sight; while Mohr and his escort, when they entered the mopane woods, were unable to repress a certain melancholy.

The most remarkable plant in Kalahari is indisputably the welwitschia. The welwitschia (*Welwitshia mirabilis*) is to be found in Cape Negro and Damara land, in places where there is little grass of any other kind, and where there is scarcely any rainfall; so that its moisture is drawn from the underground water and the night dews. This moisture and the tropical uniformity of temperature make up the few and simple necessities of its existence. The spindle-shaped axis of the welwitschia reaches in something like a century of uninterrupted growth a circumference of more than twelve feet, with its thick table-shaped ends rising only an inch or two above the ground. And this colossus, during its whole long life, only bears two leaves, its powerful seed leaves usually six, and sometimes even nine to twelve feet in length. They lie like dried sedge, rent and torn in every direction by storms and different accidents, stretched and limp upon the ground, and when they die, the plant, deprived of its life-giving organisms, is also doomed to death. The stamens, which in shape and size resemble the cones of our European firs, spring from the edge of the disc of wood that rises from the ground, and by their bright scarlet colour lend life and colour to the flower table. The nearest allied form to the welwitschia is the ephedra of the desert of Sahara; but the former is so different in the formation of the blossom and the stem, that it may be considered as forming a class of itself.



WELWITSCHIA MIRABILIS.

The Cape has nothing similar to shew, but it possesses many plants with shapeless woody body, in which sleeps a strong enduring power of growth. Perhaps the best known is the elephant foot (*Testudinaria elephantides*), out of whose globular wooden stem a slender hair springs forth as the first shower of rain heralds the wet season. A number of pelargonias possess woody knobs which live through all the drought, while every other organ dies. The slender stems of the kussonia, with their bushy crown of leaves, form globular masses of wood of considerable size in the ground, and there are many other examples of wooded plants with special organs either above or below ground, which serve as storehouses for reserve vital force to be used whenever the circumstances are favourable for growth. The importance, nay, the necessity, of such organs is shewn by the different functions of the green leaves, which not only act as respiratory organs, but also absorb the carbonic acid of the air, and assimilate it together with the juices sucked up by the roots; that is, transform it into a life-giving nourishment, a process somewhat similar to that of digestion in animals. The reserves stored up in the plant are drawn up every time when the first leaves are to be formed from a seed, a bulb, or on the stem, stripped of its leaves by the inclemency of the year; and it is just this universal distribution of organs containing reserve stores which renders possible the existence of the vegetation that astonishes the traveller in the Karroo district. In summer, Lichtenstein tells us, the sun parches the soil until it is as hard as brick. All vegetation is destroyed, except in the case of a few succulent plants, such as mesembryanthemums and the roots of *gorterieæ berkheyæ*, and asters, together with the bulbs of liliaceous plants, which kindly nature has wrapped up in a tenfold network of woody fibres, and so protected them from the pressure of the hard burnt clay. As soon as the cooler season sets in, and the rain penetrates to their resting place, the fibres absorb the moisture, and expand the clay in an upward direction, while within their sheltering cover the young germ is soon developed. The next fall of rain finds the earth already loosened, and the stem ready to shoot forth, and in a few days the ground is covered with a carpet of rich green. Soon after this change a number of buds, clustering blooms, bells, and cups begin to appear; the mild noonday sun opens the mesembryanthemums, and the *gorterieæ* expand their coronets of brilliant colour, until the young green is almost hidden beneath the gay hues of the unfolding flowers. The air is filled with aromatic, almost overpowering fragrance, especially when the sun is setting after a quiet day, and the warm breath of the flowers rests undisturbed above the plains. At this hour the scene, lately so desolate, and now so rich in bloom and beauty, is enlivened by the presence of strange visitors. Antelopes come down in long processions from the heights, accompanied by flocks of long-legged ostriches, and the colonist leaves the snowy mountains to drive his sheep and cattle into the rich healthy pasture lands, where they may lay in a stock of health and strength for the coming summer months' drought and scanty fare. Long parted friends and neighbours meet again, and spend the interval of pleasant rest in each other's company. For it is a light task to watch the flocks and herds; no sheep strays from its fellows, no ox falls down some precipitous steep, no onslaught of lion, leopard, or hyena is to be feared, as there is no lurking places where the enemies of the flock can lie in wait. There is no strife among the herdsmen, for the large pasturage is common ground, and yields plenty of food for all. But how soon does all this life and spring-like beauty pass away! Unless there comes the rare chance of later showers, the Karroo loses all its beauty in a month at the outside. The increasing heat and absence of rain destroys the plant life in its first youth. The blossoms quickly fade and fall, the stems and leaves dry and wither, the hardening soil crushes the germs of the young growth, and only the succulent plants can prolong their life against such unfriendly influences. Gradually the trenches become dry, the springs begin to fail, and when they have altogether ceased, the colonist is forced to drive his cattle back to their home in the hills. The plain is left with deep regret, and sometimes the patient sheep, inured to thirst, remain for awhile, seeking their fodder from the juicy leaves of the mesembryanthemum and other plants of the same nature, which are both food and drink and physic to the woolly tribe. But the Karroo grows more desert-like every day, and toward the end of September it is again a barren wilderness. The hard loam splits open into deep cracks, and shews the traveller the power of the African sun. Every scrap of green has vanished, the foliage of the more enduring plants is covered with a grey tint; the same vaporous grey appears upon the leaves of the succulent plants, and hides the colouring matter in the inner cells. A blackish dust, formed of the fragments of dead plants, covers the hard reddish soil. Below it lie hid the seeds of a future generation of plants, and the black dust will be their only manure when next year's rain wakes them from their winter sleep, and bids the new germs sprout. But woe betide the colonist if the rain tarries too long, for then the life of his sheep and cattle is in great danger.

The following statistics will give a good idea of this richness of blossom and of the herb flora of the Cape. Among bulbous and tuberous plants there are, according to Harvey, 590 liliaceous and amaryllidæ; 300 sword lilies (*Ixia*), and 150 orchids. Esenbeck counts 359 grasses. Among other species of the Cape flora are found 400 shrub-like heaths, 290 mesembryanthemums, 160 pelargonias, 160 ragwort (*senecia*), 148 *aspalathus*, 114 everlastings (*Helichrysum*), 105 wood-sorrel (*oxalis*), 100 *agathosoma*, 94 krassula, and 88 indigo plants, a richness of variety unknown among ourselves in Europe; for even the richest German form, the sedge (*carex*), which, to use Linden's expression, is a vexation and a weariness to the botanist, has only 76 varieties.

Still more inhospitable than the Karroo is the Roggefeld. Without

EUPHORBIAS AND ALOE (*E. candelabrum, E. tetragona, A. arborescens*).

grasses of any kind, and clothed only with small scrub a foot high, of cephalotaceæ; it is changed at times, being wholly without water, into a perfectly bare, rocky desert, scarcely able to nourish the scanty succulent plants. Even the acacias disappear from its southern slopes, and are not seen until we reach the Gariep, along whose banks appears the first river woodland.

Among the juicy plants so characteristic of this region are tall trees and herbs nestling close to the ground. Our illustration represents the two tallest euphorbia trees (*Euphorbia candelabrum* and *E. tetragona*), one of which resembles the aloe tree in form, while the other, with its dark-green, almost black colouring, and its branching shape, is like a bundle of the snake cactus. Cactus plants are not natives of the Cape; but the opuntia has become naturalised both here and in the Mediterranean district of North Africa, and appears as grand shrubs sometimes eighteen feet in height. In many places aloe forests (*aloë vulgaris*, etc.) form the distinguishing feature of the neighbourhood.

The appearance of the tree aloe (*aloë arborescens*) is as interesting as it is picturesque; for the variety of which we are speaking casts off the old leaves, and so forms a slender, upright stem, which bears aloft its yearly crown of leaves. It is a beautiful sight to see them at their best; the whole forest bright with the branching flower-stems, the flowers themselves pressing close together their masses of flaming orange-red. The tube-shaped crown is full to overflowing with rich nectar, which rises like a pearly drop from every blossom, inviting birds and insects to a luxurious repast. Human epicures sometimes join in the festival, and drink the honey-dew from the aloe blossoms, carrying on the pleasant occupation with such eagerness that the orange-red flower dust stains their faces from ear to ear, until they look more like painted savages than civilized Europeans.

The aloes of commerce are obtained by cutting the succulent leaves close to the base, when the sap runs out in large quantities into a trench previously made ready to receive it. The thick tough mass is then thickened, and packed in cases.

Side by side with the bare, stiff-growing euphorbias, and the aloes with their clusters of red flowers, is found another succulent tree growth, the purslane tree (*Portulacaria afra*), to about twelve feet high. Its round fleshy leaves are much liked by the elephant. The *portulacariæ* and the Boer plant (*Schotia speciosa*), a leguminous plant, with feathery leaves, give a distinguishing character to the singular physiognomy of the African coast scenery.

The fleshy-leaved mesembryanthemums are exceedingly beautiful. Here and there among the dark green of the clustering, finger-shaped, three-edged leaves shines the lovely citron-coloured blossoms, as large as a man's hand. A few steps farther on, at the foot of a thick bush, two other varieties are seen, one of them with small orange-coloured, the other with dark-red flowers, and as the traveller bends down to admire them he sees with delight, rising from a low thicket of rushes, a dark-leaved variety, with magnificent pale pink blossoms two inches in diameter. It is difficult to know which specimen to gather first for our collecting box, but a sudden slip of the foot warns us to proceed with caution, and on stooping down to find out the reason of our fall we find that it was caused by a delicate little variety half covered with turf, and vegetating close to the ground, on which rested its white blossoms. And this wealth, found also in the sandy downs near Port Elizabeth, is so much the more remarkable because the mesembryanthemums, of which the best known varieties come from the Cape, and are sometimes grown in our gardens, as the ice plant (*Mesembryanthemum crystallinum*), are the true pioneers of plant life. For their fallen capsules which are scattered everywhere by the play of the wind, remain closed in drought, repeating the mechanism of the rose of Jericho, and only open to scatter their seeds when the moisture necessary for germination reaches them. They are very hardy and contented, and are able to wrest a sufficient livelihood from the barren sand. But not only do they prepare the sandy soil for the reception of other plants, but some of them, particularly the kind called, from its edible leaves, the Hottentot fig (*Mesembryanthemum edule*), disappear as soon as other plants begin to appear, just as the pioneer retreats further into the interior of the forests as soon as the peaceful settler takes up an abode within his clearing.

The wax plant (*Myrica cerifera*) is a native of North America, but it is now found wild in the neighbourhood of Cape Town. Its berries yield a large quantity of wax, which is collected and used in the same way as bees-wax. As it may seem strange to many of our readers to hear of a fruit covered with a layer of wax, we may remind them that the rich vaporous bloom of the ripe plum or purple grape, and many kinds of leaves, is nothing else than wax.

Although there is no lack of grasses indigenous to the Cape, yet they are no longer found there in such overwhelming predominance as in tropical Africa. Grassy savannahs extend from Natal and the Kalahari across Caffraria, where they are useful for the breeding of cattle in the border districts of the colony, but they end westward in the neighbourhood of the great Fish River. The quantity of grass is not enough for the support of the flocks and herds, either on the plains of Karroo or the terraces of the west and the south. The steppe grasses are here driven out by grassy herbs and half shrubs of the family of *Restiaceæ*, plants which serve for the manufacture of ropes, but are of no use as fodder, owing to the hardness of their blade.

One of the most singular productions of the Cape flora is the palmita sedge (*Prionium palmita*), by which certain rivers are preserved for a long period from drying up in their channels. This grass lily, which resembles in class and form of the leaves the American bromelia, forms a dense covering of vegetation over the surface of the water. The close ranks of spongy stalks below the water are attached to the river-bed by a strong root, and bear a crown of foliage; they act like a dam to the running water, absorbing it, and checking its advance. They prolong the fall of the river, and by their thick leaves protect the surface from the fierce rays of the sun. Lichtenstein, who described this beneficent action of the water plants, observed that when the dry bed of a mountain stream was filled by the return of heavy rain, it took four days for the water to advance over a space of thirty-one miles through the palmita sedge.

The thickets by the river-side are full of interest, and abound in new and rare plant forms. Along the great Fish River the wildest thickets of shrubs extend far into the interior, mixed with so many succulent plants, that even in dry weather the woods cannot be destroyed by fire. The crowded growth leaves not an inch of ground unoccupied, and the thicket, with its sharp thorns and hard woody twigs, is more impenetrable than the primeval forests of the tropics. It is the home of the great pachydermata, in whose track the marauding Kaffir is able to follow, stealing and creeping along where the white man cannot go. The ground water of the river increases the energy of the plant growth, and the luxuriant leaves of the *scitamineæ* unfold under its influence. In such dense woods as this we find those forms of the Cape flora which, as the production of a moist soil, appear so foreign to the climate of this country: luxuriant ferns (*Todea*), even a fern tree (*Hemitelia*), lianas (*Vitis capensis*), and asclepiads, especially *Cynanchum obtusifolium*, a scitaminea (*strelitzia regina*), and an arum (*Richardia*), the two latter forms long since familiar to us all as ornaments of our houses and conservatories.

There is nothing particularly new to be said about the herbs and grasses of the Kalahari; they either resemble the forms seen in the steppes and deserts as succulent plants (mesembryanthemums and euphorbias) and bulbous plants, or they indicate the climatic connection existing between Kalahari and the Soudan. The amount of grass is very great. It grows in separate tufts, like the grass of the steppes, but the space between the tufts is not always bare, but overgrown with gourd plants, whose juicy fruit and tubers afford to many animals moisture which is denied them by the soil. In wet seasons, wide tracts of land are densely clothed with South African water melons (*Citrullus caffer*), and then all the beasts of the desert assemble to feed upon the fruits, and the Bechuanas follow them with their herds. But even when the ground appears completely parched and dry, it contains a store of food and of organic life. Many of the asclepiads possess large edible tubers, from whose juicy tissue the natives appease their thirst. Even edible berries are found in the desert, although the only moisture they obtain is received from the dew, and like the shell-fish and corals of the sea, which collect within their shells and stocks the scanty lime afforded by the sea, they store up moisture in their roots, to give it forth again for the wants of others.

The simple plastic construction of South Africa is one reason why the vegetal forms of the Kalahari are not mixed together, but spread uniformly over a large tract of land. In the northern districts, near the Soudan, acacia woods are chiefly found. They are often described as impenetrable, but it seems to be the fault of the thorns rather than of the trees, for Anderson states, as the greatest proof of their impenetrability, that the canvas covering of his waggon was torn in pieces. On the south-west, the acacia woods are bounded by the thorny bush of the Damara land. But the thorny acacias are not uniformly distributed; in one place they appear as impenetrable thickets, in another in groups, or even singly, in the midst of a landscape adorned with rich pasture grounds. It is only upon the higher-lying plains that the grass becomes scanty, and the thorn bush meagre. In the centre of the continent lie the open desert spaces: the true Kalahari, with its loose drifting sand, which stretches on without much change along the Cape territory and through Great Namaqua into the uninhabitable coast district of the west, while in the east they pass into the moist savannahs of the Transvaal.

When the summer rains set in in January, the vegetation of the Kalahari bursts into life, not gradually, but as if by the touch of a magic wand, the parched plain becomes a garden of flowers, in less than a fortnight a fair picture of living growth had succeeded to the dead solitude of the desert. Countless tiny blossoms covered the ground, and wherever the eye turned, it met the bushy groups of the tarchonanthus, with its down-covered leaves, rising to the height of thirteen to seventeen feet above the grassy plain. But even when the rain which has fertilized the dormant life of the earth has ceased, and the reign of death comes back to claim its mastery, there yet remain isolated places where the ground water maintains some possibility of life, and creates a peculiar flora, characterized by its powers of greater endurance. Even at a considerable distance the native is able to distinguish certain groups of woody plants, which, like the white thorned acacia, grow also on the shores of the Gariep, accompanied by reed grasses (*Phragmites*), and he hastens toward them to find the subterranean water which their presence reveals hidden beneath the sand, and which is so rare in the desert.

The country through which the Gariep flows is a parched and gloomy plain; the deep river winding like a green ribbon between its steep banks fringed with bushy shrubs. Coloured tracts of sand, grey, yellow, red, and purple, intersected by weather-beaten rocks of greyish white, extend to the horizon, and over all broods the deathlike silence of the brazen sky. The land is sombre and desolate, but there is busy life stirring upon the river banks. In the deep, tranquil lagoons, which the swollen stream has dug for itself on each side, and which it leaves filled when it sinks back into its bed, where, on the rich green willows, elegant grass-woven nets hang down, and bright-plumed birds rock and sway upon the feathery tufts of the sedge, a lazy hippopotamus is seen from time to time emerging from the water, and resting his head upon the grassy rim with a snort of pleasure. Suddenly the dry sedge crackles; a dark mass rushes through it, breathing hard, and, turning

·om side to side, a rhinoceros comes up from the dry plain to slake its thirst nd feed upon the green juicy twigs. Yonder descends a flock of monkeys, he old ones carrying the young ones on their backs, and calling one to nother with shrill, staccato cries, that sound as if uttered through a powerful peaking trumpet. They also are come down to drink the water. Gliding hrough the sedge and rushes, and searching every inch of ground with its irge questioning eyes, the brown diving wild goat (*Cephalophus mergens*), he long-horned *Oryx capensis*, the unwieldy koodoo (*Strepsiceros kudu*), nd many other thirsty creatures. In former times the stately elephant razed by the green banks adorned with bright blue lilies, but he has long go retreated into the interior. At night is heard the strange whining of the potted hyena, which comes to look for any decaying animal matter washed p from the waters. In the early dawn the lion and leopard lie lurking in he long sedge and tall tangled rushes, waiting for the antelopes (*A. euchore*) vhich come to drink before sunrise. At the same time comes the wild uffalo (*bos caffer*); and, scenting the dangerous guests, stamps furiously upon he ground, puts down its mighty head as if to offer battle, but thinking etter of it, turns, and is off like a shot, lashing its flanks with its long tail, nd disappearing in a cloud of dust along the plain. Here and there a eautifully spotted civet cat lifts its head from out the bushes, and looks autiously round, then puts out with lingering hesitation a black velvet paw; ut seeing something alarming, its eyes flash, and with an angry growl it isappears again.

The river itself is no less full of life and movement. In one place beaver is seen busy with his carpentering among the pieces of wood; onder moves idly and clumsily a large unwieldy turtle; wild ducks fly low, nd ruffle the surface of the river, snipe dart in swift flight from one reed ush to another, and the nimble tribe of beccassines play in the sedge or ive into the clear flood. In the shallows the long-legged purple flamingo truts along by the side of the changing coloured snake-necked bird (*Anhinga lotus levaillantii*); and by the side of the lagoon the grey crane stands on ne leg in philosophic repose, and gazes motionless into the silent waves. rom the bushes fringed with the countless white bells of the *Calla Æthiopicæ* resounds the shrill cry of the guinea-fowl, with the loud call of he francoline and pheasant.

The fauna of South Africa is richer and more diversified on the south-astern point of the Cape, between Port Elizabeth and Grahamstown, than in he whole area extending for ten degrees to the north toward the interior of he continent. On the more barren plains, where the grass is scanty, a urikate (*Rhycæna tetradactyla*) and an earth squirrel (*Sciurus setosus*) are ound. Both these animals live a social life in large buildings slightly levated over the ground, some of them having as many as twenty exits and ntrances wide enough to admit of a man's fist being inserted. Wherever the arth squirrel dwells, we are sure to find numerous large shrewmice. The igh grassy plains are covered with hills of moles, the jackal (*Canis meso-nelas*), polecat or African zorilla (*Rhabdagale mustelina*), jerboa (*Pedestes affer*), porcupine, blind rat (*Bathyergus maritimus*), the interesting earth pig, rcycterope (*Orcycteropus Capensis*), and the short-tailed armadillo (*Manis emminkii*).

In marshy places, fish otters, a kind of weasel, and many different species of rats abound. The rocky slopes are peopled by numerous tribes of baboons (*Cynocephalus ursinus*) elephant shrewmice (*Macroscelides typicus*), black spotted civet cats (*Viverra civetta* ?), servals or wild cats (*Felis serval*), caracals (*Lynx caracal*), jumping mice (*Dipus pedetes* ?), a special kind of rabbit, reddish-haired gazelles, and numerous specimens of the rock rabbit (*Hyrax capensis*). In the high grassy plateaus, with their isolated groups of bushy shrubs, we find, together with the earth pigs and armadilloes mentioned above, two kinds of gazelles (*Cephalophus mergens* and *Calotragus campestris*). Dense low stretches of bush extend for miles, and shelter the striped and spotted hyena, brown hyena, called shore wolf (*Hyæna brunnea*), civet hyena, called earth wolf (*Proteles lalandii*), and among numerous rodents a giant mole; there are also two other kinds of gazelles, the beautiful *Tragelaphus silvaticus* and the blue gazelle (*Neotragus cœruleus*). Tall bushes, clothing the wide slopes, are frequented by baboons, monkeys, grey wild cats, foxes, leopards, the koodoo antelope, the wild pig (*Potamochœrus Africanus*), the buffalo and the elephant, as well as a kind of hyrax, which is found living upon the trees.

The leopards of the coast districts are much more dangerous than in the uninhabited districts of the interior, where they are less accustomed to the crack of the rifle. As they are very terrible enemies, especially when wounded, they are generally killed by poison or caught in traps. The Boers call all leopards tigers, and they say that great havoc is wrought among the flocks by their nightly visits. The farmer who confides his sheep to the care of black servants is very glad when his shepherds keep goats, for he knows that the leopard prefers those animals; and that if the goats graze together with his flock, the enemy will be certain to choose them, and leave the sheep unharmed. The leopard is also fond of the flesh of baboons; and sometimes this preference leads him into trouble, for if he is caught at his murderous work by the tribe to which his victim belonged, he is followed from ravine to ravine, and stoned. The apes (*Cynocephalus ursinus*) are exceedingly strong and large, and if encountered in great numbers, they are dangerous opponents, and many a hunter has had to pay dearly for killing a member of the tribe. They defend their wounded or slain comrade, and often carry him away with them. In the vineyards, where they are very frequent visitors on Sunday, when the keepers are at church, they are sometimes caught in cages with trap doors, ears of maize being used as a bait; but it is usually only the young ones who are captured, the tender and prudent parents sending them out first to reconnoitre the ground. The captured monkeys are often seen chained up in yards, and teased in every possible way to make them exhibit their droll anger and grimaces.

It is forbidden by law to track or hunt elephants, so that there are still a few wild herds of twenty or thirty animals to be seen in the Cape, while they have been completely extirpated in the Orange State, the Transvaal, and the southern Bechuana land. Thanks to this impunity which they enjoy, for it is necessary to obtain leave from government to kill a single specimen, the elephants are very daring, and form a decided contrast to their kindred in the north. In Central Africa a shot fired some thousands of yards away will put to rout a whole herd, and cause them to trot off for several miles without daring to stop. It is unheard of that an elephant should attack a man without provocation, although, during the last twenty years, more than 7,500 e'ephants have been killed by Europeans. But in the district between Port Elizabeth and Grahamstown it is necessary to be very careful not to come in the way of these vagrant giants.

It would take up too much space to enumerate more in detail the great variety of birds, and we shall only name the most singular and interesting species. Several kinds of bustards, as the great blue otis (*Otis cærulescens*) and the little black otis (*Otis afroides*), animate the scene; the latter angrily greets the unwelcome intruder on his solitude with a grating screech, which at once betrays his presence, while the large and small *Otis caffra* and *Otis kori* rush swiftly through the tall grass, looking carefully around, and ready to spread their wide pinions at the first alarm of danger. These bustards, with guinea-fowl, partridges, heathcocks, sand-grouse, snipe, rainpipers, wild ducks, and wild geese, fill the hunter's bag daily. Besides these game birds, there are numerous birds of prey, first of all the carrion vulture, and several very beautiful falcons and kites. On the rocky heights above are often seen the eared owl (*Bubo capensis*) and the hooded owl (*Stryx capensis*). The secretary bird (*Gyperoganus serpentarius*) deserves special notice.

This useful bird is placed under the protection of the law, a distinction which it merits for the great services it renders to the colonists. It struts to and fro with all the official dignity of a policeman, its plume erect at the back of its head, and suddenly spreading out its wings, half running, half flying, it pounces down upon a snake or a lizard, following the turns and twists of its prey with great cleverness. It has a keen eye for the vagrant reptiles of the field, and everything which comes under its piercing gaze is at once transferred to its crop. There in safe custody snakes, lizards, locusts, beetles, frogs, and young turtles are found together, being gobbled up and devoured without any distinction.

A new and delicate charm is often added to the beautiful plant forms by the presence of birds and insects. Sometimes it is the gorgeous honey-suckers (*Nectarinidæ*) seeking their food from the great chalices of the sword-lilies or

SECRETARY BIRD (*Gyperoganus serpentarius*).

the gleaming clusters of the aloe tribe. Sometimes we see the glossy dark-green leaves of a dwarf shrub swaying to and fro, although not the slightest breath of wind is stirring. We draw nearer to see what moves the branches, and behold a whole flock of tiny singing birds are busy in the crest of the tree, seeking their insect food. Finches of every shape and colour, especially the estrella, abound here, and are sometimes so hungry and importunate, that the farmer has to have recourse to cruel measures to protect his gardens from the little robbers, and the poor things are poisoned wholesale by seed steeped in strychnine or arsenic, and then scattered on the fields. From the crest of the protea (*Protea grandiflora*), beautiful shrikes and fruit thrushes hold their survey. The roads are bright with the so-called plover (*Charadrius coronatus*), which is distributed through the whole of South Africa; and a bird called trotter (*Tachydromus bicinctus*), which, keeping to the road, runs with great swiftness in front of the horses, and then spreading out its narrow pointed wings, flies on a little way in advance, and then repeats the same manœuvre again and again. But even the sedgy parts are no less rich in the feathered tribes of the air. Reed-singers, yellow and fire-coloured finches and weaver birds keep the slender stems in constant movement, swinging to and fro, while the valleys resound with their sweet chirping.

The nests of the weaver birds (*Ploceidæ*) and the hermitage sparrow (*Philetarius socius*) are very singular. The latter birds live in thousands under one roof. When they have found a place for their nest, they all begin to build the roof, which is to shelter the community. Each pair builds and guards its own nest, but every nest is close to its neighbour's, and when they are all built, the structure looks like one large nest with a roof, and numberless small round holes in the lower part. The same nest is not used for the second brood, but the new ones are built underneath, so that the roof and the old nests serve as the covering of the new ones. Thus the mass of building increases every year, until at last it becomes too heavy for the branch to support, it breaks off, and falls to the ground.

CAMEL THORN (*Acacia girafæ*), WITH SPARROWS' NESTS. IN FOREGROUND A MIMOSA WITH NESTS OF WEAVER BIRDS (*Ploceus*).

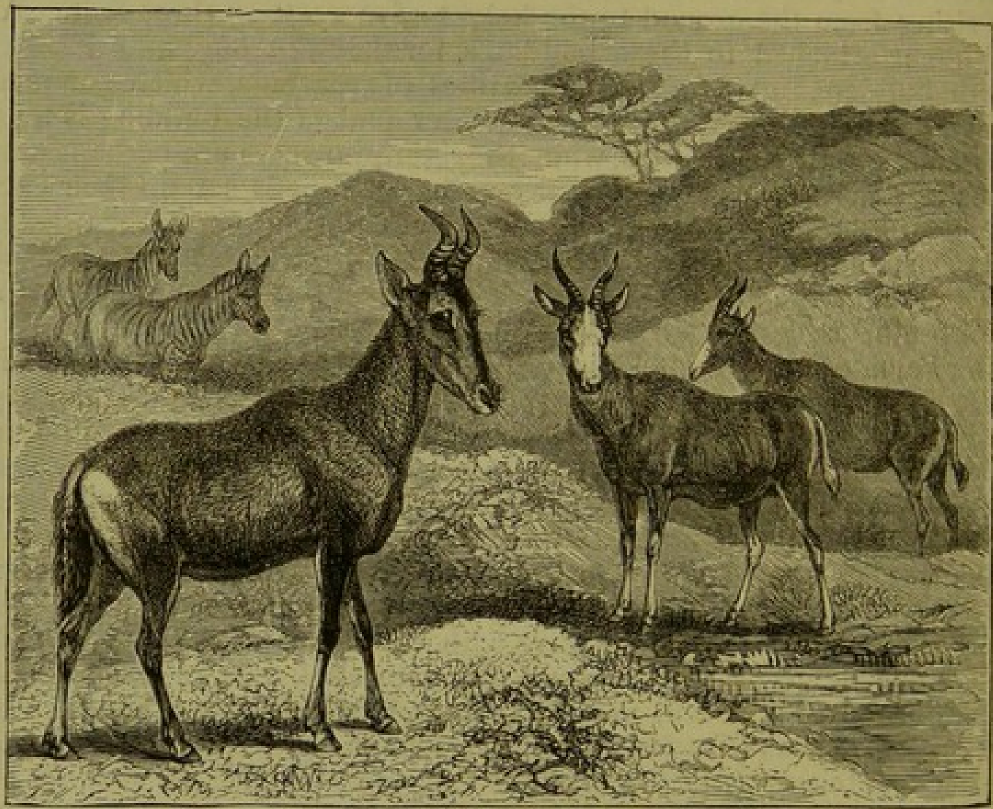
The reptile family is represented by the iguana, a giant lizard, which is found in all streams of running water; there are also a great number of land turtles, and one kind found in both running and standing water. Very many kinds of snakes, some of them poisonous, especially the puff-adder (*Vipera arietans*), cobras, horned vipers, coral snakes, and others; among the water snakes are some beautiful, harmless, green kinds, and also some exceedingly poisonous sea snakes, which are said to swim up the rivers from the sea. Sheat-fish is the kind of fish most chiefly met with, and there is a peculiar kind of carp (*Abrostomus*).

The lower animal world is also fully represented. "Water beetles," says an African traveller, "played in the brook which rippled along the ravine, and numerous water insects danced on the surface. In the bushes on the river-side lurked spiders of grotesque shape, and I saw, for the first time, large spider nests. One nest as large as two hands, closely woven of leaves and of the remains of prey, was suspended by strong threads to the branches. Upon examination it was found to be inhabited by numerous spiders, of such essentially different species that it seemed as if several different kinds were living socially together. Often a large bird-spider (*Mygale*) is found lying in wait for its prey behind the leaves, and nimbly scuttles off through the twigs and branches as soon as a stranger draws near." The *galeodes* spider, centipede, and scolopender are often seen. It is worthy of note that among all these busy creatures, beetles, bees, and flies, small forms are scarce, and that every kind is on an average of a size which surpasses the European species. It seems as if smaller organisms were incapable of supporting the parching heat of South Africa, a supposition which is borne out by the fact that smaller beetles are found almost exclusively in damp places, in water or dung. A characteristic feature of the steppes are the termite hills, the cupola-shaped domes rising from the ground to the height of more than three feet. A rich animal life is attached to these buildings, for they not only afford shelter to the earth builders, but even to hostile tribes of true ants, which conquer portions of the fortress. Sometimes the greater part of the building is found in the possession of these usurpers, while the rightful owners are perhaps crowded together in a narrow space. Several small quadrupeds set up their encampment in the termite hill, hollowing out the dome from within, as the orycterope, a kind of jackal, and others, besides which the hill gives shelter to many uninvited guests of the insect tribe which live upon the termites, and to many kinds of beetles and insects friendly to the builders.

The fauna of the great plains of the interior, near to Kalahari, and in the desert itself, differs in many ways from that above described. "The prospect," writes Holub, "presented to me and my companions, as we looked out across the wide-spreading plains before us, is never to be forgotten. We saw a grassy plain more than a mile in width, extending from south to north, bounded on the east by mimosa woods, and joining here several open spaces to a neighbouring grassy plain. This carpet of dark green, covered with the countless low red-brown termite hills, (the tall grasses only growing here and there by the tarns of water), was alive with thousands of animals of all kinds. Its numerous denizens were clothed by nature's hands in coats of varied colours, dark brown, black, yellow, red, and pale brown. They consisted chiefly of blue gnus (*Catoblepas gorgon*) striped gnus (*Catoblepas taurinus*) white-faced antelopes (*Bubalis albifrons*), hartebeests (*Bubalis caama*), a kind of gazelles, and quaggas (*Equus vel hippotigris quagga*). Some were grazing, others playing and teasing each other. Yonder came a herd of gnus, quietly walking along one behind another, as if in deep contemplation. In like manner the white-faced antelopes grazed, while a herd of quaggas one hundred and fifty strong, moved off in wide curves toward the south. Countless hartebeests, feeding in smaller herds, kept, as is their wont, closer to the bushes; blue gnus, in bands of from ten to eighty, were scattered all over the plain, which swarmed with gazelles in every direction wherever the eye turned. Additional life and animation was bestowed on this charming scene by the singular bird world. First of all came the large bustard, then two varieties of dwarf bustards, wild geese (*Chenalopa*), ducks, plover, ibises, cranes, fish herons, including probably the giant heron (*Ardea goliath*), rain pipers, and others, striking us by the bright hue of their plumage and gracefulness of form, flying generally near the ground, and by the variety of their twittering and gibbering."

Writing from Blomfantein, Fritsch describes a similar picture. Besides gnus (*Catoblepas gnu*), herds of white-faced antelopes and gazelles animated the scene, covering the plain as far as the eye could reach, until they were lost upon the horizon, appearing only as coloured streaks upon the grassy plain. Sometimes the odd array of ostriches marching in rank and file, with regular beat of their pinions, passed over the field at a quick run. At times the plain is visited by less welcome guests; a swarm of locusts settle down upon it, the rush of their myriad wings and the noise they make in eating up the grass sounding curiously like a hailstorm. These evil pests, which rob the farmer of his scanty crop of grass, have two enemies, a thrush (locust bird, or *Turdus gryllivorant*) and a stork (large locust bird), said by Holub to be a true African species (*Ciconia Stanleyii*), and by Fritsch to be no other than our own European stork on his winter wanderings through Africa. It is said that our stork, which is common in Caffraria, was not known in South Africa until the time of the German immigration; the truth probably being that the stork, which is not a constant visitor, and only appears in locust-plagued years, was not known to many of the inhabitants.

Plentiful as game is in the Quagga flats, it is nevertheless very difficult to bring down a single animal. Even the lash of the bullock driver's whip, heard from afar, scares away the



WHITE-FACED ANTELOPE (*Bubalis albifiore*). QUAGGA (*Equus Quagga*). IN BACKGROUND, ACACIA TREES (*A. girafæ*).

game, and makes the district look poorer than it is. The best plan, therefore, is to go on in advance for an hour or two on horseback, to enclose the game, but even then the chase consists more of riding than shooting. On the first day of the chase Holub did not succeed in bringing down one of the beautiful antelopes which were present in thousands; and the troops of natives, when they hunt upon the plains, only kill a single head of game every two or three days at the most.

Among the animals which are principally hunted are the quagga, tiger-horse, (*Equus Burchelli*) wild goat, eland, kanna (*Busephalus Oreas*), giraffe, and ostrich. The gnus, the dappled antelope (*Hippotragus leucophæus*), hartebeest, and a half-bred kind (*Acronotus lunatus*), together with the smaller kinds of antelopes, cannot be overtaken in the chase, and are only captured by carefully reconnoitring the peculiarities of the ground, and cutting off their retreat.

If we try to obtain a final and conclusive view of the characteristics of the South African fauna, we find that there are indications of a wealth of forms rivalling that of the flora; but animals are so much less bound by soil and climate, that most of the original peculiarities are now lost in consequence of the long-continued interchange of species between them and those of the vast area of the East and West African sub-region. But although many groups are found which extend as far as West Africa, Abyssinia, or Madagascar, and yet may owe their origin to South Africa, there are still a large number of indisputably native species; indeed, Wallace considers that the number of characteristic mammals is greater than that of any other of the African sub-regions. Among the insectivora we have the gold (*Chrysochloridæ*) and the elephant shrew-mouse (*macroselidæ*); civet cats (*viverrida*) are represented by three characteristic species, among which is the surikat (*rhycæna tetradactyla*); beasts of prey include the civet hyena, the fox dog (*Otocyan caffer*), with its immense ears, and the hyena dog (*Lycaon pictus*); the latter, however, is also found in many parts of East Africa. The rodents comprise several interesting forms, among others the jerboa or Cape hare; the shore-digger (*Bathyergus suillus*), and a mouse (*petromys*); lastly, there are a north-east and a south African variety of the earth pig. The birds, although they do not present so many characteristic forms, are yet very interesting, especially the thrushes, fruit-thrushes, fly-catchers, shrikes, sunbirds, weaver-birds, and larks, together with the Cape pigeon (*Œna*). There are eighteen characteristic forms of reptiles, four amphibia, one of fishes, seven of butterflies and one hundred and seven of beetles; among the latter are sixty-seven of the goat-beetle, an enormous number when we remember that the generally open character of the country is not favourable to the development of this group of insects.

The attention of man is directed in South Africa more to the animal than the vegetable kingdom. It is true that since their introduction by Europeans almost every European cereal and vegetable is cultivated, together with a considerable number of fruit trees, apples, pears, pomegranates, cherries, oranges, mulberries, walnuts, etc.; and wine (Cape wine), coffee, tea, sugar-cane, and cotton; but the peculiar character of the land is more fitted for cattle breeding, and the chief articles of export are accordingly skins and wool, the latter representing the fleece of ten million sheep.

Besides wool, which is the staple product, and far outweighs any other article sent into the markets, there are skins, ivory, and ostrich feathers. Within the last few years attempts have been made to introduce a better breed than the native fat-tailed sheep, of which the fleece is quite useless for manufacture; but when one is accustomed to the fine Schleswig wools, none of the kinds hitherto selected seem very good. One bad quality of the Cape wool is caused by the presence of the prickly clover (*Zanthium spinosum*). This plant is probably of South European origin, and adheres to the fleece, from which it has to be removed by special machines. In the preparation of the wool, the clover with its prickles looks like little tendrils, and is drawn out to its full length, and woven in with the fleece, the thorny points sticking straight out, and spoiling the touch of the texture. The wool procured from the northern side of the Gariep is so dirty that it is considered of less value than the former kind, and brings down the price still lower; the soiled appearance is caused by a very minute prickly grass about one-sixth of an inch long, which cannot be removed by any machine.

Ostrich farming, which is yearly attaining greater proportions, must not be altogether passed over. In the year 1865 there were only eighty tame ostriches in Cape Colony, in 1875 there were no less than 33,247, and now it is estimated that there are more than 100,000. As every full-grown bird gives about one hundred feathers of the best quality, such as are sold in Port Elizabeth for ten shillings each, and generally fetch twice as much in the European markets, we have a sure basis on which to ground our further calculations of profit. The number sent out from the Cape in the year 1864 was 17,873 lbs. (one hundred feathers to a pound), making a total value of £817,500. In 1874, 36,829 lbs. were sold for £2,055,000. Between the years 1868 and 1874 the price per pound in Cape Colony went up from £3 8s. to £5 12s.; and in Natal, from £2 2s. to £6. Meanwhile the consumption in Europe has greatly increased during the same period of time. England alone, which received only 3,988 lbs. of feathers in the year 1850, imported in 1854 10,282 lbs., amounting to

£46,280; and ten years later, 42,835 lbs., at a cost of £194,050; while in 1874, 106,918 lbs. were imported, costing £323,650. About one-third of these feathers were sent to England from the Cape. These statistics serve to shew the value of these articles of export, which are not in themselves particularly imposing. There is a great difference observed in the feathers which are exported from various places. Those sent from fertile, well-watered districts are long and heavy, but stiff and ugly, the shaft being too stiff; those from Kalahari are shorter and lighter, but preferred for the fine pliant shaft, which allows the tips to curl gracefully. The feathers sent from the interior are, moreover, yellowish in colour.

We have now to bestow a parting word upon the inhabitants of the sea and the coast lands. The shores of Port Elizabeth are rich in animal life. When the water retreats, and lays bare the rocks in the harbour, it is a rare pleasure to the zoologist to explore the tiny pools left undrained by the ebb tide. Countless sea anemones (*Actiniæ*), of a brilliant red colour, expand their arms like flowers in the water warmed by the sun. Here and there are seen the swaying fibres of the sabella, or a minute crab hops nimbly through the thick cushions of mossy corals covering the rock. In other places the various kinds of tooth-shell (*Chiton*) cling so closely to the rock, that they can only be dislodged by a sharp instrument. Beautiful fan-corals (*Gorgonias*) attract the eye by their vivid red and yellow colouring. A toy-shell (*Turbo marmaratus*) which is often sent as mother-of-pearl to European markets, appears here in the first rank of the crustaceæ, and together with a limpet, which adheres to the rocks in large quantities, is most numerously represented. The latter is eaten by the poorer classes of the population. A constant ornament found in the houses near the sea coast is the shells of the paper nautilu (*Argonauta tuberculata*), which abounds on the coast here. In favourable spots a fine-flavoured oyster is said to be found. Countless birds frequent the shores; several kinds of gulls, among others a large species, white, with dark-brown coat (*Larus dominicanus?*); black oyster-catchers, with red bill and red legs (*Hæmatopus unicolor*), several kinds of sandpipers (*Tringa*), and plovers (*Charadius*), which may be captured in great numbers. The sand-hills at Port Elizabeth are not very rich, except in snakes, among which the commonest kinds are the dreaded ringed-snake (*Sepedon hæmachates*) and the puff adder. Among land snails, the beautiful agate snail (*Achatina zebra*) and a large green convoluted snail (*Helix caffra*) are frequently seen. Whoever is gifted with olfactory organs strong enough to endure the atmosphere of a fish market will find in Capetown a wide field for his studies. Perfect mountains of crawfish, or *Palinurus lalandii*, soon to be diminished by ready customers, and a variety of sea-fish, are piled up every day, Sundays only excepted, by the Malayan fishermen. The ugly fish, *Thyreites atun*, which is about a yard long, and something like a dark-coloured pike, the broad little Hottentot fish (*Sargus Hottentottus*), and the beautiful rose-coloured *Chrysophrys christiceps*, are the principal kinds. Other species only rarely appear in the markets, since the kinds just named are most profitable to the fishermen. But there is one fish whose flesh is really injurious, and may be fatal to men; this is the little toad-fish (*Tetrodon Honkenyii*), only a little over six inches long, which abounds in such quantities, and is so easily caught, that a few paragraphs in the harbour regulations warn the inhabitants against the temptation. The natives know the poisonous "sea-devil" well, and are on their guard against it, but it is said that sailors in foreign ships have died in a few minutes after having eaten it.

One of the curious sights of the place is a little fishing village between Simonstown and Cape Town. It is a pretty little place, close to Chalk Bay. Hundreds of fishes are seen hung ıp in the sun to dry, whales' ribs are used for fences round the gardens and fields, whole walls ıre built up of the vertebræ of the great sea monster, stairs made of its shoulder bladės, and he colossal jawbones figured as the entrances of the huts. It was curious to see how every ɔart of the fish had been turned to account, and furnished the clearest proof that the whale vas no stranger in these waters. One of the inhabitants of the fishing station was kind ɛnough to offer us a great dainty, a piece of the flesh of the whale's jaw, cooked in fat; and ince there should be no disputing about matters of taste, we did not contradict him even ıfter we had been induced by curiosity to swallow a little of the stuff, which, as a matter of act, was horribly like train oil. (Scherger.)

THE MADAGASCAN SUBDIVISION.

In the Indian Ocean, about 270 miles from South Africa, lies the island ɔf Madagascar, called by the natives Nossindambo, or the land of pigs. ɔ80 miles long, and rather larger than the German Empire, it is generally ooked upon as an island belonging to Africa, although its flora and fauna listinguish it as forming an independent region, and give rise to the belief hat, together with the neighbouring islands of the Seychelles, Mascarenes, Amirante, and Comoro, it is the remains of a former continent, which, rom its characteristic inhabitants, the lemurs, has received the name of Lemuria.

Except in its south-western portion, the coast of Madagascar is very low, nd consists of a marshy plain about sixty-five to ninety miles wide, and conaining many small lakes. In the north and east an abrupt mountain land ises from the plain like a fortress wall of rock, graduated in terraces toward he west, and in the south losing itself on the plain. This mountainous disrict is formed of five chains, running more or less parallel with the longiudinal axis of the island, and joined together partly by plateaus and partly y narrow valleys. The central chain consists of primeval granite, with an verage height of 4000 feet; but marine and volcanic forces have also helped o mould the surface of the island, as is shewn by the numerous craters, and y the masses of sand and red clay which cover the plains and make up a *ırrain*, upon which nature bestows her gifts in most unequal measure, in ne place with lavish profusion, and in another with a grudging and stinted and.

The eastern coast is blessed in every season of the year with fertilizing ains, and is therefore fringed by an unbroken line of woodland.

Among the most striking vegetal forms of the woods is the traveller's ree (*Ravenala urania speciosa*), a tall pisang, with a fan-shaped, spreading osette of leaves. The stalks of the flowers, where they join the stem, are unk into hollow cavities, which absorb and retain the rain, and when pierced ive out a draught of refreshing water. Especial attention is attracted by an rchis (*Angræcum sesquipedale*), living on trees, with flowers nearly eight inches n diameter, armed with spurs sometimes twenty inches long, and the trellis lant (*Ouviranda fenestralis*), a water plant, of which the long leaves are ɔrmed of a perforated network of veins like woven tulle. In the woodlands f the low-lying coasts the prevailing tree forms shew an admixture of African nd Asiatic types; the acacias which are seen in every part recall the Soudan, ıe pandanus form and the casuarinas remind us of the Indian archipelago. ˈot only in the indigenous, but also in the immigrant vegetation, both along ıe coasts and in the mountain forests, this dual type of forms is observed, nd is explained by the fact that while Madagascar, by its geographical osition, is connected with the Soudan, in its climate it more closely resembles

India. The small number of palms (six) correspond to the character of the African flora; one of the largest kinds, a sago palm (*Raphia ruffia*), distinguished by its unusually large leaves, generally is found among the forest trees, another (*Areca Madagascariensis*) belongs to an Indian type, the rest form a peculiar species of reed palms (*Dypsis*). The flora is even allied to that of the Cape by a kind of heath (*Philippia*), which is also a native of the latter country, and is found in Madagascar, on the outskirts of the forests in the hill country. The aspect of the woods, the great number of ferns, and a peculiar kind of pitcher plant (*Nepenthes*), correspond to the scenery of the more humid Indian landscapes. The mountain forests are rich in woody lianas, and filled up by an impenetrable thicket of undergrowth. Here is the true home of ferns, sometimes the undergrowth is entirely composed of them, and on the tall trees air-plants (*Epiphytæ*) are found, though they often consist of ferns only. Unfortunately, all this luxuriant and splendid vegetation, with its costly woods, its wealth of trees abounding with copal, benzoin, and incense wood, but also with the poisonous *Tanghinia venenifera*, is doomed to destruction; for the natives burn down the trees unsparingly, partly to gain more land for cultivation, but principally to use the burnt ashes as manure; and the beautiful forest region is soon destined to become a pestilential fever swamp, as the coast district is already. The jungle thicket which extends along the coast is as dangerous as any to be found in India; giant grasses, sedge, and sage plants spring up from the muddy ground, and form a peculiar vegetation, to which isolated ravenalas and languishing pyramid-shaped cypresses (*Vacoa pyramidalis*) impart a singular character. The poison-laden air of this place, where even the natives dread to penetrate, is the home of venomous snakes and fearful crocodiles.

Above the region of the ravenala and ruffia palms rises that of the bamboos. Then come the savannahs, apparently resembling those of Africa, but containing also many ferns, among others the European *Osmundo regalis*. Leaving these plains, and journeying still farther westward, we enter a wide solitude of sandy plains and barren plateaus, until the thickets of the western coast come in sight. This description of the vegetation of Madagascar needs further confirmation to establish its accuracy; for the interior, and especially the southern parts of the island, are but little known as yet. The chief objects of culture are rice and maize, but besides these cereals, spices, cocoa-nuts, indigo, sugar, and tobacco are exported.

The fauna of Madagascar is tolerably rich in mammals, although the latter belong to a very limited number of families and orders. The country is specially characterised by its numerous lemurs and insectivora; it possesses also a few exclusive species of carnivora, but most of the other groups so richly represented in Africa are entirely wanting here; there are no apes, lions, leopards, hyenas, zebras, giraffes, antelopes, elephants, or rhinoceroses, even porcupines and squirrels are absent.

Madagascar possesses only eleven of the forty different families of land mammals found on the continent of Africa, thirty-four kinds of lemurs and the curious aye-aye (*Chyromis Madagascariensis*); eight kinds of bats, eleven of insectivora, including the tanrek (*Centetes ecaudatus*), nine kinds of beasts of prey, with eight civet cats (*Viverridæ*), and the feline *Fossa* (*Cryptoprocta ferox*). The last-mentioned animal is a confirmed marauder in the poultry yard; it is about fifty-four inches long, and is dreaded by the natives to such an absurd degree, that instead of attacking it, they throw aside their weapons, and, trembling in every limb, climb up the nearest tree for safety until the robber has disappeared within the forest. Pigs are represented in Madagascar by the Potamachœrus, and rodents by three kinds of mice. The majority of these and all the other known animals are found in the woods, but it is probable that there exist many other kinds as yet undiscovered. A hippopotamus was found in a half-fossilized state, proving that at no very remote period the hippopotamus must have lived upon the island.

Madagascar is exceedingly rich in birds; already eighty-eight genera, with a hundred and eleven species of land birds, have been discovered, and every year new species are added to the list. Out of all these kinds only twelve are found upon the adjoining continent; and these twelve are either birds with strong pinions or widely distributed forms, which now probably migrate frequently from one country to the other. Specially deserving of interest are the sparrow kind; but finches and tits, poorly represented in Africa, are not found in Madagascar. There are no woodpeckers, honey-cuckoos, wattle-birds, hornbills, pisang-eaters, buzzards, and creepers, which is the more singular, because all these families are well represented in Africa, the last three being peculiar to that continent.

Some of the birds of Madagascar are so singular that it is difficult to classify them, and they are up to the present moment a weariness and perplexity to the ornithologist. In the *Æpyornis maximus*, which from its remains some naturalists have considered to belong to the ostrich tribe, and some to the birds of prey, Madagascar probably possessed the largest of all birds, the roc of the "Arabian Nights" and other oriental stories. The contents of its eggs, which have been found well preserved in the mud, is perhaps equal to those of about 150 hen's eggs, while an ostrich's egg is only twenty-four times as large as a hen's egg.

AYE-AYE (*Chyromis Madagascariensis*).
Length, 1 yard, including tail.

The reptiles of Madagascar offer peculiar features of interest. Beginning with the snakes, we find in the great family of the adders not one of the African types, but in their place three kinds which are nowhere else found but in America. The desert snakes, both African and Indian, are represented by a peculiar species; the tree adders by *Ahætulla*, a kind belonging both to Africa and America. The fanged serpents (*Lycodontidæ*) and vipers, so numerous in Africa, are not found here. The lizards are no less remarkable; the gekkoes, for instance, are not represented by any purely African kind, but by leaf-fingered (*Phyllodactylus*), which are both American and Australian, by the half-fingered (*Hemidactylus*), found everywhere throughout the tropics, and by two characteristic species. The other groups are less interesting; the fishes and amphibia are but little known. If we consider the insects as a whole, we arrive at the following singular result, that their affinities are in a striking degree Indian, Australian, and South American; while the African element is principally represented by special South or West African forms, instead of by such as are widely distributed over the Ethiopian region. The same is true also of the land snails, in which Madagascar and the adjoining islands are very rich.

Bourbon, Mauritius, and the two Mascarenes, situated respectively about 360 and 450 miles to the east of Madagascar, are volcanic islands of moderate size. Climate and vegetation are tropical: there is no lack of rain at any time; and the rainy season lasts about five months, in Mauritius from December to April. The chief object of cultivation is the sugar-cane. The woodland districts, beautiful with all the charm of the fairest tropic scenery, is being driven back toward the hills in Mauritius by the advance of agriculture, and in Bourbon it is checked and hemmed in by lava fields.

The union with Madagascar, indicated by certain common genera, is more distinct still with reference to Africa; but most of the plant forms, in so far as they are not immigrants from India and the Soudan, are entirely peculiar to the Mascarenes. One thousand plants have been collected in the latter islands, half of which were indigenous to the soil. Bourbon yielded a still richer booty, 200 kinds being found there which are not known in Mauritius; but the latter island possesses trees peculiar to itself. The high woods which originally entirely covered Mauritius, and which in Bourbon extend up the hills to the height of 3,390 feet, are now partly cleared by culture, and are less impenetrable than in other tropical countries, because the deep shadow checks the growth of underwood. The pandanus form, and the small number of palms (six) recalls Madagascar; the six palms are, however, all exclusive forms; the madder tribe is well represented, a dragon tree (*dracæna*) is of interest among the monocotyledonous plants. Above the mixed tropical forests of Bourbon is seen an unbroken belt of vegetation formed of bamboos about forty-five feet high; and then begins the shrub region called here Ambavelle's region. They cover the ground to the height of about six feet, countless ferns growing up between them; and upon their branches, up to 6,000 feet above the sea level, are found orchids, mistletoe growths (*loranthaceæ*), and pepperworts. A number of heaths and other plants recall the Cape flora. But the most remarkable of all is an acacia (*Acacia heterophylla*), the largest tree of this region, which sheds its feathery plumes, and replaces them in part by the stems of the leaves, thus combining the characteristics of the African and Australian types, and so nearly resembling the Koa acacia of the Sandwich archipelago, that it has been mistaken for the same species, and even yet is not distinguished from it with certainty. Both kinds are subject to an oceanic climate, but the places where they grow are separated by nearly half the circumference of the globe.

The islands possess no native mammals except bats. The lemurs and tanrecs (*Centetes*) found upon them were probably brought over from Madagascar. The same thing may be said of the Comoro Islands, which, however, posses a special kind of lemur and a Malagasyan civet cat. On the other hand, the Mascarenes have several remarkable birds, especially the caterpillar shrikes and salanganes (*Callocalia*), while Mauritius and the small remote island of Rodriguez have each a peculiar kind of parrot (*palæornis*).

The extinct bird fauna of these islands is very remarkable. The best known forms are the dodo (*didus ineptus*) and the solitary bird (*pezophaps solitarius*) of Rodriguez; both of which were common in the time of Vasco di Gama. As far as we can determine, the appearance of the dodo from the fossil remains which have been preserved, and from the oil painting in the British Museum, it must have been a helpless, foolish-looking bird, larger than a swan, with ragged feathers. The fossil remains of corn crakes and short-winged herons have also been discovered. Even in our own days the number of birds in Mauritius has diminished; a peculiar type of pigeon (*Alectrænas*) having died out within the last thirty years. Snakes are not found, but lizards are well represented, and the giant land turtles (*elephant turtle* or *testudo elephantopus*), once very numerous, are only found now, and that but rarely, in Aldabra, a small island to the north of the Seychelles. Amphibia are not mentioned here by naturalists, and insects present no features of interest.

The Seychelles, lying to the north of Madagascar, form a miniature archipelago of granite islands, chiefly famed for its cocoa palms (Seychelles nut, or *Lodoicea Seychellarum*).

This majestic palm, with its fan-shaped leaves, about eighteen feet long and three feet wide, has played no unimportant part in history. It is the mother plant of the once famous "sea nut," which was prized the more because its birthplace was unknown, and it was only taken up when washed ashore or found floating on the waves. No wonder that sometimes mythical ideas were attached to it, and it was honoured as a relic. Pilgrimages of the healthy and the suffering were made to the places where even a fragment of the nut was found. It is said that the Emperor Rudolf was once unable to purchase one of these nuts for £400. As once the golden land of the one-eyed Ahrimaspes was guarded by griffins and ants as large as foxes, so was the wondrous tree which bore the sea nuts. Terror and death threatened the daring hand which ventured to approach it, the more surely because all the currents of the seas ran towards it, and engulphed the sacrilegious pirate in their whirling depths. It was thus that natural science was taught in olden days; and we, who smile in wonder at the beliefs of our ancestors, are occasionally beguiled during the relaxing heat of the dog days by newspaper stories of unheard-of sea serpents and other amazing monsters; and as to the enormous prices paid for the nut, which certainly is unequalled, at least in size, by any other nut, we may perhaps remember something like a parallel case in our own days. To keep within the domain of natural history, a fossil as large as a man's hand (*Ahalopteryx*) was purchased not long ago for £500, and an egg of the spectacled ant for £100, not to speak of the absurd value attached to worthless objects by many who are considered to be people of culture. As it is, the sea cocoa palm of the Seychelles is now found only upon two small islands, Praslin and Curicuse, and will soon become a thing of the past.

The Seychelles only possess one mammal, an Indian kind of flying fox (*Pteropus*); the twelve kinds of land birds are, with one exception, peculiar to the islands.

THE SOUTH AFRICAN ISLANDS, AND THE HIGH LATITUDES OF THE SOUTH IN GENERAL.

The islands of South Africa are in themselves of too little importance to be mentioned here, and yet they have one claim upon our consideration, namely, that they exhibit the influence exerted by the distribution of land and water upon the organic life of the antarctic regions.

Situated between Cape Horn and the Cape of Good Hope, but lying much nearer to the latter, rises the volcanic island of Tristan da Cunha. It is a steep, rocky volcano, more than 7,500 feet in height, and rises almost sheer out of the waves. Its summit is always wrapped in clouds, and the rain descends upon it heavily, and at all seasons. The thermometer seldom rises in summer to 67° in the shade, and rarely falls during the night to 45°. There is no perceptible change of the seasons, and the vegetation is consequently never interrupted. Such is the climate of an island situated at an equal distance from the equator to that of the south of Sicily, 36°. As a proof of the favourable influence of this climate upon fern growths, we find that the number of flowering plants observed on the island is no greater than that of the cryptogamous plants. On the plateau surrounding the dome of the crater at a height of 2,625 feet above the sea, and lower down in humid places, grows a fern with a woody stem (*Lomaria robusta*), often reaching a height of from three to five feet from the ground, but generally lying along the soil, and only erecting the tip of its fronds. The hillsides are covered up to the same level with a curious crooked tree (*Phylica*) which is firmly rooted between the crevices of the rock, and grows eighteen or nineteen feet high. The stormy atmosphere does not allow of any higher tree growth. The space between the shrubs is often filled by a six-feet tall reed grass; and the upper region where the phylica ceases is covered by a fine grass growth. All these plants and a few others are peculiar to the island, but no peculiar genera have been found. Only two species find their centre of distribution in the Cape; others stand in the same relationship to the more distant shores of America. No direct immigration from South Africa can be assumed, except in the case of a pelargonium. Many plants, on the other hand, are certainly descendants of South American species; and the ferns are either allied forms to those of that continent, or have been brought over from it. There is no difficulty in the way of such an immigration; for, not to speak of the prevalent west winds, the antarctic ocean current flowing eastward from Cape Horn through the southern latitudes of the Atlantic and Indian oceans, keeps up a communication between the most widely separated coasts.

The island of Kerguelen's Land is situated in 50° S. lat. (the same distance from the equator (50° N. lat.) as Lizard Point, Cornwall), and at almost equal distance from Africa and Australia. It is a basaltic rock of considerable extent, namely, 2,000 square miles, and possesses scarcely twenty vascular plants and no tree growths. A rich grassy turf, and a close-growing cushion of an antarctic umbelliferous plant (*Azorella*) make up the chief part of the vegetation, the most remarkable species being the cruciferous plant (*Pringlea antiscorbutica*). The head of this plant resembles a head of cabbage; it is used as a vegetable, and was called by Captain Cook Kerguelen cabbage. The chief cause of the poverty of vegetal life is the barren nature of the soil, and next to this the isolated position of the island, which makes immigration very difficult. During a three months' residence in Kerguelen's Land, Hooker found the plants which Captain Cook had noticed in midsummer in bloom towards the winter.

The great preponderance of water in the southern latitudes, the cloudy sunless skies and dripping ice plains, which are detached from the mainland during the summer, and by their melting waters chill the better part of the year,—all these influences unite in producing an evenness of temperature, which seems to increase as the south pôle is approached. Indeed, the seasons are distinguished, not by a change of temperature, but almost only by the increase or decrease of light. All the months are cold, but the thermometer fluctuates, as it does in the tropics, between very narrow limits—in the districts of the icebergs, between 55° and 65° S. lat. There is hardly one day throughout the summer when the temperature rises above freezing point, or sinks more than to 18° Fahr. The south winds, laden with snow, meet the northern atmospheric currents saturated with watery vapours, and rest on the surface of the seas in constant fogs, white and blinding in their denseness. These desolating mists descend also upon the islands situated near this zone, and last through the whole year, counteracting every advantage they could derive from their nearness to the equator, and forbidding almost entirely the changes of temperature which depend upon the altitude of the sun. For these reasons organic life ceases altogether already on this side of the polar circle. It is therefore somewhat remarkable that, in spite of these very contrary conditions of climate, most antarctic plants and genera are the same as those of the far north, although the varieties of shrubs and grasses found in Kerguelen's Land and Falkland Island display a richness of the turfy

ALBATROSS (*Diomedea eaulans*). Length, 98 inches. PENGUINS (*Eudyptes chrysocome*). Height, 20 inches.

soil which is foreign to the northern arctic regions, where the vegetation is suspended by a long winter sleep. Beyond Falkland Island (lat. 32° S.) vascular plants soon reach their final limit. The shrub found farthest south, an umbelliferous one, was observed by Captain Cook already in South Georgia (54° S. lat.), same latitude as Lubeck. On Macquarie Island, to the south-west of New Zealand, Wilkes only mentions tall grassy turf and the utmost limit of any grass growth is found in the islands of South Shetland (lat. 60° to 63° S.). The last vegetal life seen in the direction of the antarctic pole are the cellular plants noticed by Hooker on Cockburn Island, situated near to South Shetland, in 64° S. lat. At this point even the algæ which float on the surface of the high seas of the south disappear. They are not found either upon the continental coast of Victoria (177½° S. lat.), where, in the latitude of New Zealand, the fiery crater of Erebus, the extinct volcano

Terror, and the coast along the sea level appeared equally destitute of vegetation, a sight not to be paralleled in its desolation by any scenery found in the extreme north.

There is little to be said of the animal life found in these islands: penguins (*Eudyptes chrysocome*), puffins, gulls, and albatrosses, compose the chief part of the fauna of St. Paul's, and probably of that of the neighbouring islands. The ursine seals (*Artocephalus falclandicus*), which frequented the shores of these islands in thousands even so recently as the end of the last century, are no longer found basking in the sun, but have entirely disappeared. According to the report of the Novara expedition, it is very rare that one of these animals is seen or captured by the natives. There is not even the slightest trace remaining of the tribes of sea mammals, which only a few years ago were lying about the islands in such numbers that one had to pass over bone fields going along the edge of the crater; and no one would believe that hundreds of thousands of seals have met their death upon these shores. We must not forget to record that the insects found in Kerguelen's Land are almost all either entirely wingless or provided with very short wings; the only moth found there, together with a few flies and several beetles, were all unable to fly. As the island is exposed even in the best part of the year to violent and almost constant winds, the significance of this extraordinary absence of wings among the insect tribe can scarcely be mistaken. No insects, except those incapable of flight, would have here any chance of success in the battle for existence.

The Islands of Western Africa.

The three archipelagoes of the Azores, the Madeiras, and the Canaries, although widely separated from each other in point of distance, are yet brought into close connection by their vegetal and animal life. The flora of this island world of lava and volcanic rock has been called the Atlantic, in token of its independence, which however does not prevent its being enriched from other countries; but although the Gulf Stream visits in turn each of the Atlantic archipelagoes, and although West Indian fruits with seed capable of germination are frequently washed ashore, yet there has never been any acclimatisation of plants from tropical America. Europe is the continent from which the immigrant flora of the Azores is derived; and the immigration is made possible by the summer trade-wind, and by the immense numbers of European birds of passage which visit the islands in the winter.

The vegetation of the Azores resembles that of the Mediterranean region, inasmuch as the forest trees belong to the laurel form, and evergreen shrubs are the woody plants. In the island of Pico the evergreen region extends more than 5000 feet above the sea level; but although the moist soil is covered with such a luxuriant growth of plants, the flora is extremely monotonous. Notwithstanding the most careful exploration, the number of vascular plants discovered is less than 500, and the woods are almost entirely composed of three leaf trees, the laurel tree (*Laurus Canariensis*), *Picconia excelsa*, a tree resembling the olive, and the fayal (*Myrica faya*). The short-leaved juniper is the only native conifer. The soil is covered with ferns, among which may be found a few exclusive kinds, *Dicksonia culcita*, and some European species, eagle and royal fern.

Madeira was uninhabited at the time of its discovery; and its well-watered valleys were found fertile down to the sea coast. A tree called the island cedar gave a valuable scented wood, but was unfortunately lost in a great conflagration of the high woods. Fragments of it, it is said, may still be seen in the old woodwork of the houses in Funchal; it is probably the fragrant juniper of the Azores, or the cedar of the Canaries (*Juniperus cedrus*), which is a taller tree, but not now indigenous to Madeira. The lower part of the island (up to 1,800 feet) has been completely cleared of trees, especially on the southern side, and the land is used for cultivation. But the fertile, well-watered plains, and the boldly rising ground near the mountains, has preserved all the charms of a luxuriant vegetation, made still more beautiful by its possessing not only European, but most of the tropical objects of culture. The vine culture, which came to an end in 1852, in consequence of a disease which attacked the vines, is now replaced by the sugar-cane; but there are many vineyards still left in the island. The banana is grown everywhere. Tropical fruits, custard-apples, mangos, guavas (*Psidium pomiferum*), rose-apple (*Jambosa vulgaris*), pitanga (*Eugenia Michelii*,) a tree with dark-red fruit the size of a cherry; a kind of medlar (*Eriobotrya japonica*), pomegranates, Avocata pear (*Persea gratissima*), melon trees (*Carica papaya*), carob tree (*Ceratonia siliqua*), tamarinds (*Tamarindus indica*), oranges, citrons, figs (*Ficus cairca*), olives, and mulberries are found side by side with peaches, apricots, almonds, pears, cherries, and plums. Palms are not found, or at least only in gardens as solitary specimens.

DRAGON TREE OF OROTAVA.

Among the most peculiar forms of this flora is the dragon tree (*Dracæna draco*), a member of the liliaceæ. Contrary to the usual formation of monocotyledonous trees, it bears in full maturity a curious branching crown. Until it blossoms, its stem, like that of the liliaceous order, is single, and bears a simple rosette of sedgy leaves. But when the blossom begins to emerge from the bud at the summit of the tree, the rosette of leaves disappears, and side shoots spring forth from it. Each of these shoots repeats the process previously gone through by the original stem, so that in time the latter is surrounded by a crown of bare branches, each one bearing a tuft of leaves at its extremity. The original trunk is generally short and swollen near the root. Nothing can be more grotesque than the aspect of some of the older trees. Another claim to our interest, possessed by this dracæna, is that it seems fast dying out. Tall stems are looked upon as curiosities. The very ancient dragon tree of Orotava, described by Humboldt, is said to have been as thick and hollow when the island was taken by the Spaniards in 1402 as it was when the storm broke it to pieces in 1868. We give an illustration representing this tree.

Above the cultivated region, wherever the steeply cleft valleys or barrancas admit of their growth, a belt of chestnut trees is found ; still higher a considerable tract of land is occupied by laurels, which on the more humid northern side reaches in some of the sheltered valleys down to the sea coast. The trees are taller here than in the Azores, and there is a greater variety of species. Four kinds of laurel are known, more than twelve of other trees, about thirty shrubs, and the number of vascular plants amounts to nearly seven hundred native kinds. The laurel species are the Vinatico (*Persea indica*), the *Laurus Canariensis*, *Phœbe babusana*, and til (*Oreodaphne fœtens*). The wood of the latter species has, when fresh, an unpleasant, rotten kind of smell, which clings to it for many years. The undergrowth often supplants and dispossesses the taller laurel trees ; a pathless thicket twelve feet in height, and joined together by brambles, only leaves space for the trees to grow in isolated groups; and a luxuriant fern growth springs from the damp fertile soil. But some of the shrubs develop into trees, especially the tree erica of south Europe (*Erica arborea*) which occasionally is found with a trunk more than thirty-six feet in height.

The archipelago of the Canary Islands, situated more than ninety miles from the mainland, lies, like the desert of Sahara, right in the track of the constant trade-wind, the vapours of which are condensed into cloud upon the mountain peaks, and fertilize the northern slopes of the range. Wherever the peaks are high enough, they gather the clouds round them, which increase during the winter, and descend as rain into the low-lying regions. This fact explains the difference existing between the mountainous islands and the lower ones which lie nearer Africa. The flora of these different groups would contrast in every respect, were it not that the coast lands of all are subjected to the influence of drought. The forms of the Mediterranean region are prevalent at a certain height only, while in the lower districts the physiognomy of the vegetation is African.

The arrangement of the plant life of the Canaries must be based upon the terrace-like formation of the earth, which at the Peak of Teneriffe has been tabulated by Buchs and Berthelot as follows :—

	Northern slope.	*Southern slope.*
Region of succulent plants . . .	0 to 1,870 feet .	. 0 to 1,900 feet
Evergreen region—		
Laurels	1,870 ,, 3,700 ,,	
Shrub wood	3,700 ,, 5,000 ,, .	1,900 ,, 4,000 ,,
Region of pines (*Pinus Canariensii*)	5,000 ,, 6,700 ,, .	4,000 ,, 5,950 ,,
Region of retamas (*Spartocystus nubigenus*)	5,950 ,, .	,, 8,890 ,,
Highest flowering plants	10,000 ,,	
Barren region	8,890 ,,	(summit) ,, 13,000 ,,

The region of succulent plants borrows from the Sahara the date palm and the tamarisk (*T. Canariensis*) ; but the wolf's-milk growths, which resemble the cactus, and certain plants belonging to other families, and possessing juicy fibres, are more richly developed here than in the desert. The following are the forms which predominate on the untilled land by the mass, and the numbers of their individual specimens : a fleshy wolf's milk (*Euphorbia Canariensis*) forms upright branching prisms of more than eighteen feet high ; equally common is a fleshy plant (*Kleinea nerii folia*) which is also found in the Cape ; the undergrowth is composed principally of other euphorbias (*E. balsamifera* and *E. regis jubæ*), and of a madder shrub (*Plœama pendula*) resembling a weeping willow. The great variety of the succulent plants may be learnt from the fact that of the *Cassulaceæ* alone, more than twenty indigenous species have been found ; the vivid green fades into the bluish colouring of the succulent plants, and even the latter hue is lost to sight on the volcanic tufa, and among the rocky fragments by which the coast is covered. The dry nature of the soil has imparted even to cultivated plants a great appearance of sameness ; here, too, owing to the vine disease, alterations have been introduced, and the opuntias, fıom which cochineal is obtained, have become the chief objects of culture.

On Teneriffe, whose high peak is surrounded by a low, but wide-spreading hill country, the region of the succulent plants extends over a wide area, and in Fuerteventura and Lancerta take up the whole available space. As far as the nature of the ground admits it is subjected to cultivation, and with cultivation we find an advance of immigrant plants. But few native trees are now to be met with in the district of cultured land and succulent plants, and even in the forest region the original vegetation is being supplanted. In Teneriffe only a few of its magnificent laurel woods still remain on the northern side of the Peak. The island pine, which once formed the beautiful forests (*Pinares*) is almost extirpated here, but still clothes the mountain chain of Kanaria. In Ferro an open pine forest grows on the southern side, while leafy evergreens cover the moister northern slopes, the finest pinares are found in Palma, where, besides the pine, the native cedar (*Juniperus cedrus*) flourishes. Gomera is more abundantly watered, and consequently possesses a splendid laurel forest, which takes up the centre part of the island. Space unfortunately fails us to mention more in detail the Peak of Teneriffe, which, since Humboldt's classic narrative, has been the goal of so many travellers, and the object of so many descriptions.

The animal world of the island groups under our notice is naturally not particularly rich. The only genuine native mammal of the Azores is a bat ; the 53 kinds of birds which inhabit or visit these islands are, with one exception, all found in Europe, North Africa, Madeira, or the Canaries. Nine kinds of butterflies, and 212 of beetles have been found, of which, however, no fewer than 175 are European. In Madeira the number of land birds is increased from 21 to 28, and in the Canaries to more than 50 species, but nearly 1,500 kinds of beetles, more than 1,100 of which are peculiar to the islands, inhabit this archipelago.

A very remarkable characteristic of the beetles is the extraordinary predominance of wingless kinds. This is especially the case in those groups which are restricted to the Atlantic islands, as many of the species found there are comprised exclusively of wingless insects ; but the fact holds good also of the other groups. No less than twenty-two genera which in Europe are generally, or at least sometimes winged, have only wingless species in Madeira, and even three kinds which are winged in Europe appear as wingless in Madeira, without any other modification or change ; and the winged species of Madeira often possess larger wings than their European kindred. Darwin explains these facts by the supposition that the winged insects were blown out to sea, while only the heavier and idler species, which either could not or would not fly, were able to survive for the propagation of their race ; and that as this process is perpetuated from generation to generation, it must, according to the laws of the transmission of hereditary qualities, and of the mutilation of disused organs, which in process of time leads to the total loss of wings in those insects to whom wings were not an absolute necessity of existence. But those who had need of wings to obtain their livelihood had to be acted upon in another way. Of course, those who could fly the best were better able to fight against the wind, and place themselves in safety, and in this way the owners of the best and strongest wings were preserved, while the weaker-winged kinds perished in the struggle for existence.

To complete our survey, we may add that in the Canaries two bats, one lizard, about fifty-six kinds of land-snails, a few spiders, locusts, centipedes, and similar creatures have been found ; that the rabbit which runs wild in Teneriffe is only distinguished from its European brethren by its endless numbers of fleas ; and lastly, the welcome denizen of our dwellings, the canary bird (*Serinus canariensis*), is a native of Madeira, Cape Verde, and the wooded islands of the Canaries. The male of the wild canary has a gold-coloured forehead and marks near the eyes, while the female has a grey face and pale-green head, the rest of the plumage being green tinged with grey. Our tame canaries have therefore changed the colour of their coat, but not their quality of voice, which, according to Balle, remains, on the whole, what it was originally.

Cape Verde Islands have a tropical climate influenced by the trades, and a rainy season lasting from August to the end of October. It is remarkable that the trade-wind, which blows with great violence and without interruption except in the rainy season, brings no rainfall to the mountains of the island, although the latter are 7,500 feet high. As is the case with the Peak of Teneriffe, this may be caused chiefly by the small extent of the chain, but the distance of forests exerts considerable influence in the same direction.

The rock and boulders, unprotected by any covering of earth, become so overheated by the fierce sun, that the watery vapours are unable to be condensed. Sometimes the rainy season does not set in at all, and then all vegetal life is endangered, as it is in the deserts of Africa. Although isolated cocoa and date palms are seen, and here and there fruit trees and coffee plantations, yet it is said that four-fifths of the land lies untouched. A scanty shrubwood covers the valleys where the streams degenerate into marshes soon after the rainy season. Along the mountain slopes the rain is accompanied with a poor vegetation on the rocky plains and in the fissures of the rock, until in March the soil is perfectly dried up again, and not a green leaf remains. Native plants seem altogether absent, and only small copses of dwarf acacias, tamarisks, and *rubiaceæ* are seen. The apparently contradictory fact is worthy of notice, that the islands allied by their native plants to the Atlantic archipelago of the Atlantic zone are on the other hand connected by their immigrant plants with Africa, the continent which lies nearest, and most resembles them in climate. The same thing may be said of the as yet imperfectly known fauna, which contains no species of particular interest.

St. Helena is one of the most interesting oceanic islands, from its peculiar flora, which, however, is fast disappearing from the face of the earth. When first discovered, at the beginning of the sixteenth century, the island was covered with forests, but the goats introduced into the country multiplied to such an extent that they devoured all the young growth. When, three hundred years later, scarcity of wood was felt, the goats were taken off, and trees from all parts of the world were planted; and when Burchell (1805—1810) and Roxburgh (1813, 1814) examined the flora, the island was destitute of forests; but there were still so many fragments of the native timber left remaining, that it is possible to gain a comprehensive knowledge of the former plantations from the notes of their collections. Since that time, however, the more powerful organisms of the immigrant plants from foreign countries, and especially of the European pine, have so completely dislodged the native plants, that Hooker, scarcely thirty years afterwards, was unable to discover the slightest trace of certain trees and plants, and only the dead trunks of other kinds on inaccessible cliffs. Thus there has vanished almost before our eyes the goodly number of about forty trees of the olive tribe, which have been called gum, cabbage, ebony, and red-wood trees, a fact which is the more to be deplored as St. Helena afforded the proof that the origin of exclusively characteristic plants was possible on islands as well as on the continents. Why, however, should the geographical extent of a territory exert an influence upon the forces which produce its living organisms?

CHAPTER IV.

AMERICA.

THE FAR NORTH OF AMERICA.

ARCTIC FLORA AND FAUNA.

THE extreme north of America possesses an organic life which is not unlike that of the north of Siberia, so that the flora and fauna of both these parts of our earth may be classified as arctic, or inhabiting the whole region surrounding the pole. In both countries the short period of vegetation, which never exceeds three months, sets a limit to tree growth, but the peculiar formation of the arctic regions of the western continent allows the treeless district to advance much farther southward than is the case in our own hemisphere. The cause of this fact is found in the relief and division—in other words, the plastic formation and broken coast line of America.

Only a comparatively small amount of ice can be formed on the open seas, and that of but little strength, because the winds and storms and the warmer water which rises from the depths to the surface can at any time dissolve or break it up. We see, then, that the unusual broken character and the great extent of coast in the American arctic archipelago is one reason why so much more ice is formed there than in the north of Asia. These masses of ice become still larger by the addition of the immense quantities of glacier ice sent down from the mountains of this island world through the deep clefts of the valleys to the bays, sounds, channels, and straits.

In every geographical latitude it is only the mountains which erect lasting piles of ice and snow; for as the snow water, melted by the sun's heat, flows down their slopes, it imparts to the snow crystals, as it freezes again, the granular formation of the glacier ice, which sinks down to the valley, and hardens into a glacier. In the plain, on the other hand, the melted water sinks into the ground, passing quickly through the substratum of snow. When there, it can certainly freeze again, according to the average heat of the climate; but this subterranean ice, which forms such a characteristic feature in the north, becomes mixed with the stones and clods of earth underground, and exerts no chilling influence upon the surface of the earth, which is warmed by the sun, unless it stops the flowing off of later formed streams of melted snow. In this case it produces those moist and marshy plains which we have learned to know in Asia as tundras, and which in America constitute the true arctic desert. How relatively slight may be the influence of the underground ice is best seen from the steep walls and banks, from thirty to sixty feet high, of apparently solid ice on the coasts of Kotzebue Sound, near Behring's Straits, which, covered by a layer of earth and vegetal substances only three feet deep, bear a luxuriant vegetation. Wherever, as here, the construction of the ground allows all the water to run off, and at the same time is well situated with respect to the sun, the combination becomes highly favourable to vegetation; and accordingly the river valleys in the region of the arctic flora, in the immediate proximity of glaciers and tundras, form the best pasture grounds, and, comparatively speaking, produce the richest vegetation. The most striking contrast to these valleys is presented by Greenland, a hilly country, abounding in glaciers, where organic life is found only upon the coasts and on the banks of the fiords, which are free from ice in the summer, and penetrate deep into the heart of the country, while the glaciers precipitate their floating icebergs into Baffin's Bay, and the currents carry them southward until they break up and dissolve in far warmer latitudes.

The two factors necessary to remove the icebergs of the arctic seas are ocean currents and the heat of the sun; but Hudson's Bay affords no outlet for the southward drifting ice, and the narrow Labrador current can only

ICELAND MOSS (*Cetraria Islandica*). Natural size.

slowly carry off the enormous masses of drift ice floating in Baffin's Bay, some of which have come as far as from Melville's Sound. A great part of the winter's ice has therefore to be melted on the spot where it lies by the sun's heat; and the places where this happens, especially Hudson's Bay, become centres of cold, which extend their chilly influence over all their surroundings. What a contrast between Europe, whose coasts are kept free from ice by the warm waters of the Gulf Stream, up to lat. 71° N., and so fitted for the growth of forest trees, while near Hudson's Bay the limit of tree growth ceases in lat. 60° 30′. And even 1,300 miles farther southward these climatic differences are by no means equalized; for New York, which is situated in the same parallel of latitude as Naples, has a summer like that of Rome, but a winter like the winter of Copenhagen, its average temperature being 51°; while that of Brussels, which is situated 10° farther north, is 50·5°.

The tundras of America are lichen tundras, and not the moss tundras of Asia. Wherever the ground is loose, without any solid coherence, it is covered in wide stretches with the greyish white of the earth lichens, especially *cornicularia* and *cetrariæ*, which change to a grey brown as the moisture gradually penetrates the earth. Among them we recognise the well-known reindeer and iceland moss (*Cenomyce rangiferina* and *cetraria icelandica*). As the soil becomes firmer and more mixed with stones, a number of low shrubs, seldom as much as four inches high, are seen above the carpet of lichen. But these dwarf shrubs, of which Hayes "covered a whole forest with his hat," often develop their underground organs to a very great extent in a horizontal direction, "the stem of a willow a few inches high could be traced for about four yards below the ground, without coming to the end of it." This fact is the more important, because almost all arctic plants are perennials with underground stems, while annuals which only leave seed in the winter are altogether unknown.

The lichen tundra is much more favourable for animal life than the

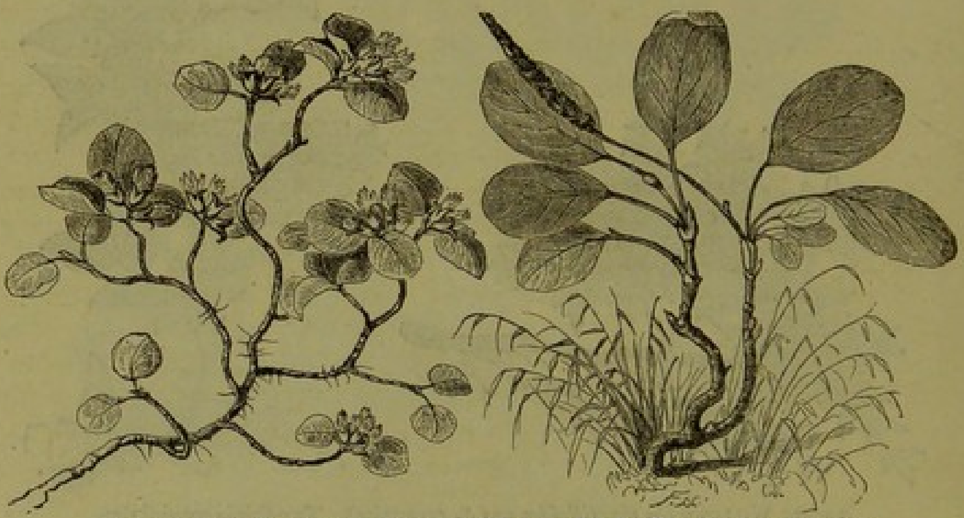
ARCTIC WILLOWS (*S. myrtilloides and S. pyrenaica*). Two-thirds natural size.

moss tundra. The lichens afford that nourishment for the animals of the tundra which they cannot obtain from the mosses; and accordingly we find the tundras of arctic America frequented in winter by herds of reindeer and of sheep or musk oxen (*Ovibos moschatus*), animals of about seven feet in length, which combine in a singular degree the characteristics of the sheep and the ox. This animal, notwithstanding the great amount of nourishment which it requires, finds it wants amply supplied in the remains of vegetal life buried under the snow, and remains in the tundra, without roaming to the forests farther south.

As the winter sets in very suddenly, the juices of the grasses and other plants are retained within their tissues, and frozen so that they retain their nutritive properties, and preserve their seeds for the coming spring, untouched by the corrupting influences of autumn or the withering breath of winter. The dwarf berry-bearing shrubs of the tundras, cranberries and crowberries (*Vaccinium* and *Empetrum*), often found in great abundance among the lichens, afford food in autumn to the bears and the migrant arctic geese, and are preserved unchanged beneath the snow, until the ground is dried by the rays of the summer sun, when the fresh blossoms immediately unfold their petals.

The berry-bearing shrubs grow side by side with a few willows, an *andromeda*, and a rhododendron (*Rhododendron lapponicum*), and are intermixed with some herbs; red-flowered anemones, yellow ranunculi and poppies, dazzlingly white starworts and chickweed (*Stellaria* and *Cerastium*), two kinds of silver-weed (*Geum* and *Dryas*), the reddish daisy (*draba*), spoonwort (*Cochlearia*), purple maiden-hair (*Saxifraga*), and lousewort (*Pedicularis*), dandelion, bluebell, knotgrass (*Polygonum*), even an elegant little fern, are found; while in the moister places grow grasses, sedge (*Carex*), rushes (*Juncus*), and cotton grass (*Euphorbium*); the latter, not like that of our climates, with a dazzling white fruit, but generally having the top of its fruit covered with brown or reddish hairs.

All travellers seem to agree in the statement that these regions only possess two seasons, a nine months' winter and a three months' summer. Naturally such a climate is not favourable to cultivation. In the garden of the Danish governor in Holstenberg, a settlement lying on the western side of Greenland, and immediately below the arctic circle, we are told that cabbage, turnips, lettuce, rhubarb, and sorrel are cultivated. They require great care, while cucumbers can only be raised in a greenhouse, and then only of moderate

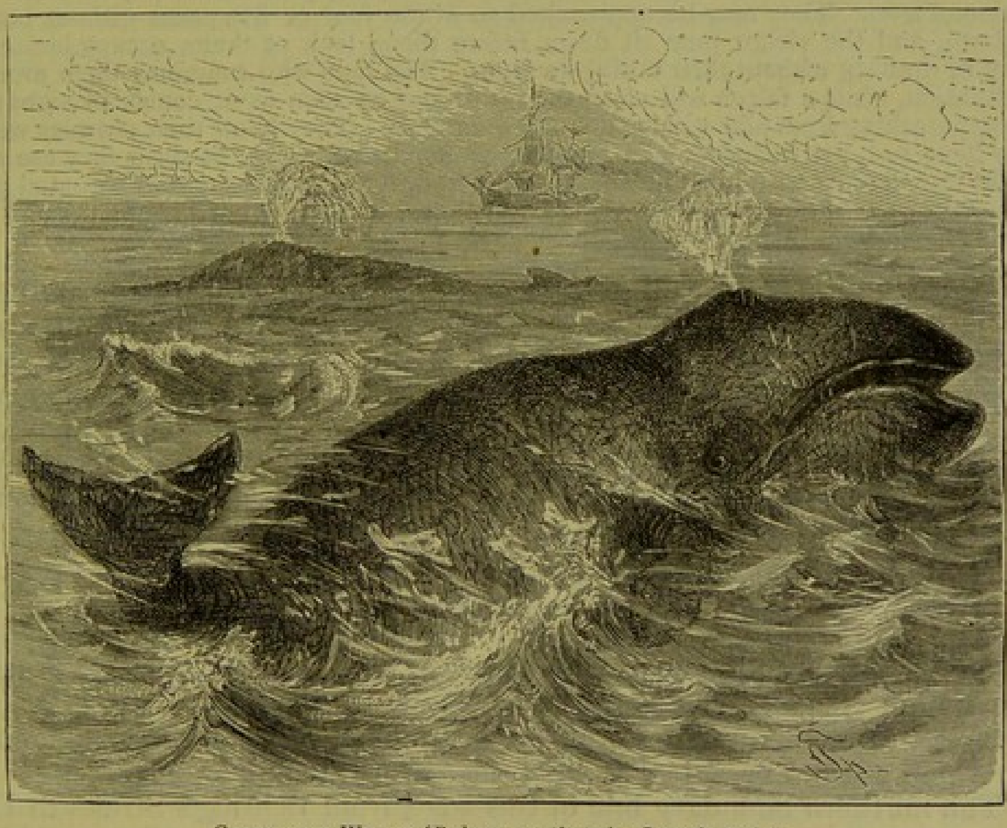


ARCTIC WILLOWS (*Salix herbacea and S. reticulata*). Two-thirds natural size.

size. If the plants can be protected from the cold winds, many of them grow to great luxuriance, notwithstanding the relatively low temperature of the air; for in these latitudes the days are long during the summer, and for some time the sun never sinks below the horizon; so that the conditions of vegetation are much more favourable than they are among the Alps, for instance, in places possessing the same average summer temperature. The attempts at corn-growing, made first by Egede, were repeated later, but without success. Here and there a little barley is sown, but it is only developed sparingly, and scarcely attains to the formation of the ears. Strawberries, it is said, thrive under glass, as well as they do in Denmark, but the potato meets with serious obstacles to its growth. The plant never blossoms, and the yield is only three or four times the amount of the seed sown, the tubers being generally small and watery.

The animal world, without being exactly rich in its number of representatives, is of some importance and very interesting. The musk ox, arctic hare (*Lepus glacialis*), and a lemming (*Myodes toquatus*), are peculiar to the northern districts of America. Among the mammals are the polar bear, ermine, arctic fox, wolf, glutton, reindeer; and above all, the marine mammals, the whales and seals, deserve notice. The only domestic animal is the Esqu maux dog; for the Americans do not know how to tame the reindeer, although it has the same qualities as that of the old world.

For centuries past large fleets have set out for the capture of the valuable sea mammals. In the year 1661 the Dutch equipped thirteen whalers; in 1788, 235 English ships were occupied in the northern whaling expeditions, and when in 1848 the American vessel *Superior* passed through Behring's Straits into the Arctic seas, and made a good haul, she was followed in the next year by no less than 154 sail; and from a table drawn up by Scammon, 19,943 vessels were sent out to the whale fishery between 1835 and 1872, capturing and destroying about 290,000 whales, and gaining more than £50,000,000. A great number of these fish were obtained from the northern Arctic seas, of which the chief mammals are the following: four species of



GREENLAND WHALE (*Balæna mysticetus*). Length, 60 feet.

whales, including the Greenland, Finland, and Narwhal; walrus, four kinds of seal, and the sea dog.

There are but few birds permanent in these regions, but numerous migratory birds come here to breed. Of birds which are known beyond all doubt to exist beyond 82° N. lat., the American expedition to the North Pole mentions the arctic falcon (*Falco arcticus*), snow owl (*Stryx nyctea*), raven (*Corvus corax*), snow bunting, rock lapwing (*Strepsilas interpres*), sand-piper (*Tringa maritima* and *canutus*), ptarmigan, sea-swallow, several gulls, stormy petrel (*Procellaria glacialis*), ringed goose, arctic duck, eider duck, loon, merganser (*Mergulus alle*). A little farther south are found the magpie-auk (*Alca torda*), swallow (*Hirundo horreorum*), and others.

One of the best descriptions of the wonderful wealth of birds found on certain cliffs, or so-called bird mountains, has been written by Nordenskiöld. The scene, although observed in Nova Zembla, is equally characteristic of the American arctic cliffs. "The fog which until then had veiled the neighbouring coasts was suddenly torn asunder, and revealed a wonderful spectacle. Close to the ship, and on each side of her, rose two precipitous mountains, whose terraced slopes were literally covered, as far as the eye could reach, with myriads of birds. By their jet-black backs and white breasts we recognised them as loons. Dignified, immovable, pressed close one to the other, so that not a stone could reach the ground between them, they were hatching their eggs. Others rose in the air in countless numbers, but all flying in the same direction. Here and there was seen a gull, or high overhead a *Larus glaucus*. Many of the loons (*Uria troile*) suffered themselves to be rocked to and fro on the crests of the incoming waves, now and then plunging their bill into the water for the fish on which they live, while others pecked away at each other furiously, in the struggle to obtain the best breeding place.

Even when we landed, nothing was seen but birds, a few geese being noticed among them; while the sea displayed its riches by a whole shoal of dolphins, twelve to fifteen, or even eighteen, feet long. Any one who visits a bird mountain frequented by loons no longer wonders that these birds are called stupid, when in their breeding places they pay no heed to the presence of man. They may be approached to within four or five paces without betraying any alarm, and the visitor may sit down before them, look at them, occupy himself with writing or drawing without their taking to flight. The man who examines them arouses no apprehension, while a falcon will clear the whole cliff as soon as it comes in sight; a sea eagle approaching from afar will scare away thousands. They know their enemies well, and if they have not yet included man among the number, it is only because they are seldom brought into contact with him; indeed, they are known to become shy after repeated pursuit. The numerous bird mountains are visited every year, and a rich harvest of eggs and young birds is gained from them.

There is little to be said of the lower land animals: the gnats are not less importunate here than in Siberia; glacier fleas are common, and a few butterflies are also found, including the *plusia gamma*. Beetles are scarce, but the wealth of the seas and tributary waters in fish, crabs, and crustaceæ is inexhaustible; how otherwise, indeed, could the monsters of the deep and the myriad aquatic birds support life as they do, and yet leave an abundant supply for the wants of man? The naturalist and explorer find here a rich field of laborious but remunerative work.

The Zone of the Conifers.

This designation is intended to comprise that part of the North American forest region lying to the north of the United States, not as if it consisted exclusively of coniferæ, but simply to distinguish it from the non-coniferous trees which are the prevalent type of the forests of the Union.

The northern boundary line of this zone, from Behring's Straits to Labrador, is, according to Griesbach, the region of the *Pinus alba*, or white fir, which often represents in America the pine of the eastern hemisphere, and with the less frequently seen birch (*Petula papyracea*), grows farther northward than any other conifer of that district, farther even than the North American larch (*Pinus microcarpa*). The white fir is sometimes found in sole possession of the soil; its forests extend in the interior of the continent, without a break, across fourteen degrees of latitude (68—54° N. lat.), and by the Saskatchewan, directly up to the prairie lands. The only relief to their sombre monotony is afforded by the river banks, where the woods, besides fir (*Pinus balsamea*), contain also willows, alders, and poplars. These trees are protected from the underground strata of ice, which at Fort York (lat. 57° N.) are sixteen feet thick, by the formation of their roots, which only penetrate to a slight depth below the ground, and when they reach the ice, which in the summer time does not melt, develop in a horizontal direction, just as if they had come in contact with the solid rock.

The arctic limit of corn-culture extends in the interior of this forest zone farther north than in Siberia. Almost uninhabited, and used only as hunting grounds to supply the fur trade, the Hudson's Bay territory is anything but a corn-growing country, and yet it has perhaps a greater future before it than Siberia can hope for. At Fort Simpson, in lat. 62° N., the latitude of Yakutsk, where the corn-culture of Siberia ceases, barley is sown in the latter half of May, and ripens in three months; but even at Fort Norman (65°) it yields good harvests in favourable years, and potatoes and several kinds of kitchen vegetables are obtained. The difference depends upon the influence of the frozen strata of earth, which in the more friable soil of Siberia extends deeper than in the Mackenzie, where the accumulation of subterranean ice is checked by the granite rock. The masses of ice being larger in Siberia, and their temperature far below freezing point, they do not thaw so much as in America. We are told that the cornfields of Yakutsk are free from ice in summer to a depth of three feet, while in the same latitude on the Mackenzie the ice is ten feet below the surface.

Manitoba, of which so much has been written within the last few years, is situated in the same parallel of latitude as Paris. The thermometer never rises above freezing point from April to November, but there is little snow, and all that remains upon the ground is so loose and granular that even on the lake Athabasca (55° lat.) horses are left all night in the open air, and can find their food underneath the thin covering of snow, a feat which would be impossible in the more southern states of Iowa and Wisconsin. The long winter is followed by a short uncertain spring, but then by a hot summer, ripening maize, melons, and other plants which are only found in the southern countries of Europe. This region seems to be the original home of the now widely spread water plague, *Elodea Canadensis,* which has become also the torment of Europe. Much damage is also often done by fires, inundations, and locusts, which extend their ravages over twenty degrees of latitude, from the Llanos estacados of Texas to the Saskatchewan, and destroy in a short time the produce of many thousand acres of land. It is said that in the Hudson's Bay territory about 200,000 square miles, or an equal area to that of France, is capable of cultivation; besides which there are 340,000 square miles of forest; 60,000 square miles of excellent pasturage; and 1,200,000 square miles hunting grounds.

The transition from this northern zone to the more southern region is effected in Newfoundland by the milder, or rather the less severe, winter in Canada, by the increasing heat of the summer, and in the far west of the Pacific coasts by the uniform mildness of both seasons.

The west coast of Alaska, as far as the mouth of the Oregon (46° N. lat.), possesses a uniform climate, with abundance of rain in every season of the year. The coniferæ are found here in dense and stately forests; the trees growing to an unusual height, especially a series of firs, the Douglas, Menzies, and hemlock firs (*Pinus Douglasii, Menziesii,* and *Martensiana*), together with the Oregon cedar, or yellow cypress (*Thuja gigantea*). But the forests are not composed solely of coniferæ; maple, poplars, alders, and an oak resembling the German oak (*Quercus garryana*) are found also. Lastly, on the upper Oregon the prevailing form is a resinous Scotch fir (*Pinus ponderosa*) 140 feet high.

It is no unusual sight to see the stem of a Douglas fir 200 to 240 feet high; indeed, it is said that some of the stems measured were more than 270 feet. But the open coast being exposed to the frequent western storms, many of the trees are blown down while in their prime. In some places the ground is so thickly strewn with the trunks of young and old trees, that it reminds us of the formation of the carboniferous strata. The tallest tree of the east is the White pine (*Pinus strobus*), which in our own woods is not taller than an ordinary pine.

The islands near the coast, Vancouver and Queen Charlotte Islands, possess large and luxuriant forest lands, full of most valuable timber trees. They are well fitted for cultivation; but while in Vancouver a great variety of vegetables and hops are grown, the Indians of Queen Charlotte Islands only cultivate potatoes, which they export to British Columbia.

A third forest zone is found in Canada, of which the flora gradually changes into that of the Atlantic states of the Union. This is the zone of trees with periodic leafage, which, gradually beginning to dislodge the conifers near Lake Winipeg, cover the whole of the lowlands toward the south, and display great variety in the trees of which they are composed—among others, oaks, elms, ash, and maple. These are the forest trees which, together with the leaf-bearing shrubs, make the glory of the far-famed Canadian autumn, displaying in the splendid colouring of their leaves every variety of tint, passing from palest yellow through orange to vivid red.

Except in Newfoundland, the high woods of America seem never to have been cleared to any great extent, so that the shrubs only deserve notice as undergrowth. In the south the laurel tribe is represented by several rhododendrons (*Rh. maximum*), and on the Oregon is found our garden favourite, *Mahonia*. Heaths are altogether wanting. A common leaf-bearing shrub is the *Comptonia asplenifolia*. From the island of Sitcha to the Oregon, an ivy bush (*Fatsia horrida*), nine to twelve feet high, is very common, and remarkable for the strong yellow thorns of its dense bushes, which soon bar the traveller's passage through the forests. Meadows, as in Europe, are often found beside running water, and in some places, for instance near the Oregon, are distinguished for their nutritive grasses (corn and *festuca*). Many of the western heights are crowned by tufts of succulent grasses. A singular feature of the country is the wild rice (*Zizania aquatica*), which is found in great abundance here and near the Red River, as well as by the countless lakes of Minnesota and Wisconsin. It covers many marshes, and not only supplies the inhabitants with nutritious food, but also attracts a great number of moor fowl and aquatic birds.

If we include the region of the conifers in that of the United States, the united floras would receive an addition of only twenty-two plants. Some of these, however, would be very valuable species, such as the white fir, the pitch pine (*Pinus rigida*), yellow pine (*Pinus resinosa*) of New Scotland, while the true yellow pine (*Pinus mitis*) penetrates the states of the Union as far as Georgia.

The island of Newfoundland forms a separate zone, where the trees, black and white fir (*Pinus nigra* and *alba*), larch, and birch, are of a moderate height, scarcely more than eighteen to twenty-seven feet; and the forests which clothe the hills are everywhere broken by tracts of open country with mossy turf moors, and on the drier hills with the northern berry-bearing shrubs.

The fauna of this zone has much in common with that of the arctic regions, especially as far as regards its birds; it is more sharply defined towards the south. The glutton, lemming, reindeer, and moose deer (*Alces Americana*), scarcely appear in the southern districts; nor do the polar bear and arctic fox.

The musk ox is not known here. Among widely distributed animals are the racoon, a tree porcupine (*erethizon*), a mouse (*Jaculus Hudsonius*), and the beaver (*Castor Canadensis*); while others are restricted to certain localities—the skunk (*Mephites mephitica*), for instance, is only found in Nova Scotia and Canada.

If we examine the mammals a little more in detail, instead of merely mentioning them in their typical representatives, we find that the first place is claimed by the grey or grizzly bear (*Ursus cinereus*), the giant relative of the European land bear. Next in importance comes the black bear (*Ursus Americanus*), which is distributed over the whole of North America, and the wolf and fox, represented by special forms resembling our own.

The fur-bearing animals deserve particular attention. The region is eagerly visited by hunters, but the time is not far off when it will no longer be visited by the animals they seek; so deadly are the effects of the strychnine used for their destruction. The flesh of the racoon (*Procyan lator*) is much liked, and its fur is highly esteemed. About 20,000 skins of the arctic lynx (*Lynx Canadensis*) come into the markets every year. The marten, or American sable (*Martes Americana*), yields about 100,000 skins yearly, the finest being readily purchased at £3 15s. The fish marten (*Martes Pennantii*) is highly prized in America, and for that reason its skin is rarely sent into Europe, although the yearly value of those exported amounts to £13,000. Almost all the wolverine skins (*Gulo borealis*) brought into the market come from America, but the greater number are, like those of the marten, kept at home. About 1,600,000 minks' skins (American otter, *Putorius vison*), of an average value of twenty shillings each, are exported for sale; and strangely enough, the best skins, valued at twice the price of the western minks, come from the east coast, the same region which supplies the least valuable marten skins. Our fish otter is represented by the sea otter (*Euhydris lutris*), an animal inhabiting the extreme northern coasts of the Pacific Ocean, both Asiatic and American. About 1,500 skins, realising from £20 to £75 each, are sent yearly into the market.

The hare (*Lepus Americanus*) is one of the principal objects of the chase; and sometimes appears in such numbers on the banks of the Red River, that, without being a good shot, the sportsman may kill a hundred in a day. Occasionally these little rodents disappear almost entirely, and then increase in number constantly for three or four years; thus in the autumn of 1868 they became so scarce in the country between the Rocky Mountains and Labrador, that many of the Saulteux Indians died of hunger.

In some places the buildings of the beavers exert a perceptible influence upon the formation of the land; their dams transforming quiet brooklets, which flowed originally through the dark shadow of the woods, into a succession of ponds, some of which cover a space of more than thirty-five acres. By their side are seen the clearings, or "beaver meadows," made of the trees felled by the beavers; some of these clearings extend over more than 250 acres of ground, and frequently form the only breaks in the virgin forests. Turf plants often spring up by the side of the ponds, and thus, wherever the ground is suitable, turf moors, of more or less extent, are gradually formed. America exports yearly about 150,000 beaver skins, representing a value of £75,000. The animal most widely distributed next to the beaver is the musk rat (*Fiber zibethicus*). It is found from 69 to 30 degrees north latitude, and supplies the markets with 3,000,000 skins a year, at an average price of two shillings a skin.

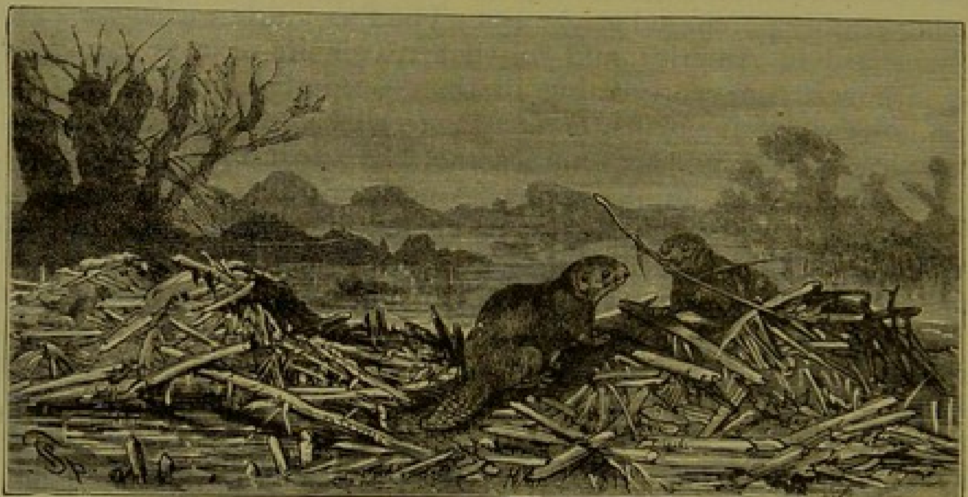
The ruminants of this region are very remakable. The bison, or buffalo

(*Bos Americanus*), is now almost extinct here, or at least has become so scarce that the law punishes the unnecessary killing of the animal by a penalty of a fine, and for the second offence by imprisonment; but there still remain, among others, the moose deer, perhaps identical with the European elk; the waipiti (*Cervus Canadensis*), larger, though less beautiful, than our own royal stag; the reindeer (*Rangifer tarandus*), and the mountain sheep (*Ovis montana*), a noble animal akin to the Asiatic argali, four feet long, found in the Rocky Mountains, from sixty-eight to forty degrees of latitude.

The number of birds, both permanent and migratory, belonging to this zone is but slight; but about two hundred birds of passage, half of which are land birds, have their breeding place here. There are scarcely any species deserving special attention; but among the breeding birds of Alaska is found a humming bird (*Delasphorus rufus*).

Snakes (five) and turtles (three) are only found in Canada; farther north the amphibia are only represented by frogs, toads, and a salamander.

The fish belong chiefly to the salmon, pike, and perch families; but there seem to be a few kinds only, and of those none are peculiar. In most



CANADIAN BEAVER ERECTING A DAM (*Castor Canadensis*). Length, 36—38 inches.

of the fur-trading stations, beside the Rocky Mountains, fishes of the salmon tribe form the principal article of food through the greater part of the year. To the west of the mountains the round fish (*Corregonus quadrilateralis*), and to the east the white fish (*Corregonus albus*) are found. The Great Slave Lake is unusually rich in fish, especially in carp, salmon, pike, and white fish; while Great Bear Lake abounds with herrings and salmon. Newfoundland is famed for its so-called "cod-fish meadows," a series of banks situated to the south-east of the island, and generally wrapped in mist, on which between five and six thousand vessels assemble every year with 100,000 sailors for the cod fishery. This, perhaps the most important fishery, obtains 400,000,000 to 600,000,000 cod (*Gadus morrhua*), sometimes 4½ feet long, and weighing up to 80 lbs., and sends it into the markets as stockfish, laberdane, etc. Along the North American coasts, the advancing armies of the cod depend greatly upon the caplin (*Mallotus villosus*), a fish resembling a salmon, and upon the cuttle fish. The former visits these localities to deposit its spawn, and forms the almost exclusive food of the voracious cod; the latter appears just as the caplin leaves the place, as if it were destined to replace the retreating fish, and to allow itself to be devoured by the cod.

Insects are relatively well represented; more than fifty butterflies and eight hundred beetles having been found in Canada.

The United States.

The whole of the eastern half of the United States, east of 100° W. long., corresponds in all climatic peculiarities. A temperature high in summer, low in winter, and an abundant rainfall, characterize the climate of the whole region, which extends almost from the outskirts of the tropics to 50° N. lat., and from the shores of the Atlantic to the heart of the continent. It would be a decidedly continental climate, were it not for the great amount of moisture carried by favourable winds from the seas of the south and the east across the land. The heat of summer is so extreme that it seems to remove the climate from the temperate zone, to which it belongs in every other respect; for instance, St. Louis, at the mouth of the Missouri, possesses during the three summer months an average temperature of 81°, only five degrees lower than that of Key West in the southern point of Florida, which is more than eight hundred miles to the south.

The climate of the western half, exclusive of California—in other words, the climate of the prairie lands—is a plateau and steppe climate, such as is observed in its greatest extent and precision in Asia, the continent *par excellence* of steppes and table-lands. Nothing is more characteristic of this climate than the absence of atmospheric moisture, which begins to make itself felt in 95° W. long., and which from 98° to 100°, together with the rapidly increasing rise of the ground, imparts to the scene that aspect of poverty and barrenness which is the characteristic feature of the highland steppes. Even without being trained to observe hydrographic peculiarities, or the details of vegetal life, a stranger could not fail to be struck by the dryness of the air, from the absence of all closeness, and the scarcely perceptible evaporation in a temperature which for weeks together in the summer time never sinks below 90°.

The number of salt lakes, salt marshes, deserts watered by salt streams, even rivers containing salts and alkalies, are among the most striking indications of this absence of moisture. Another peculiarity is that the climate is always in extremes; when it is hot, it is intensely hot; when cold, terribly cold; the rain is a deluge, the wind a hurricane. Waterspouts are characteristic of Mexico. Extremes of heat and cold, unheard of in the east, are here crowded into the space of a single day. The radiation at night is so great, that very low temperatures at dawn belong to the characteristics of the region. On the other hand, the west is less subject than the east to the greater and more wide-spread fluctuations of the weather.

California possesses a true sea climate. Oceanic winds prevail within its limits. Its coasts are washed by a current which tempers the heat of the summer; while the Sierra Nevada affords sufficient protection against the winter's cold. It has therefore only two seasons, properly so called, a dry summer and a wet winter only a few degrees colder than the summer. But it would be a mistake to compare this wet season with that of the tropics, where the rain falls in sheets, and sometimes lasts for weeks together. The rainy season of California is little more than an unusually cold, wet summer in our own country, and is by no means without occasional days of fine and sunny weather. During the summer months, from the beginning of June to the end of September, or even some way through October, slight showers of rain fall now and then by exception along the coasts; while in the interior the days are almost cloudless, with bright blue skies and glorious sunshine. This long-continued drought has a great effect upon the appearance of the scenery. The traveller visiting the more low-lying districts of California toward the end of the summer, finds almost everything parched, withered, and to all appearance dead; he looks round vainly for a spot of green, and makes up his mind that all which he has heard or read of the fertility and beauty of California is a fiction, or at least an exaggeration. But how different is the picture presented by the same landscape a few weeks later, when it has been refreshed by the rain, and wakes up to new life! The amount of rain varies considerably from year to year; and these fluctuations are sometimes fraught with disastrous results to the country. For, on the one hand, unusually violent and persistent rain causes the most terrible inundations; and, on the other hand, if the rain is long delayed, the drought is extremely injurious both to the fruits of the field, and particularly to the fodder grass. By the failure of the latter crops the cattle trade of California has often suffered severe loss. Snow is a very rare sight in the low valleys; during a period of fifteen years it snowed only four times in Sacramento, falling in thin, scattered flakes; and, except in one instance, melting away as it fell. The case is altogether different in the higher districts of the Sierra Nevada, where the snow is sometimes more than fourteen feet deep; so that the Pacific Railway which crosses the mountain chain at Summit Station, at a height of 6,636 feet above the sea, had to be protected against the snow storms by special snow roofs. These snow fields are of great importance to California; they feed the rivers, and the latter supply the trenches and canals which keep up the necessary amount of water in the mines. If the mountain crests are high and wide enough to receive and store up a large quantity of snow, they distribute sufficient water to enable the land to produce rich harvests; but if the summits are low or narrow, the mountain slopes and the valleys at their base are alike unfruitful.

From the close connection which exists between plant life and climate, the vegetation of every larger portion of the globe is a true mirror of its climatic peculiarities. We find here, too, that the region of plant distribution is bounded by the same limits as the climatic regions; and that the three divisions of the forest lands, the prairie and steppes, and the Californian coast region, correspond in all essential points with the regions of the Atlantic, the inner continental, and the Californian climate.

A strong trait of similarity to the vegetation of Europe and Northern Asia runs through the whole North American flora. Not only has North America families and genera common to Europe, and sometimes to Central Asia, but the resemblance extends in many cases to the species; and the greatest part of the North American species of plants possess at least a general similarity to the European, North and East Asiatic, and even to North African forms. If this universal resemblance between European and North American vegetation is surprising to those who expect to find in America a new world, the naturalist, whose studies have prepared him for the likeness, is the rather astonished at the sharply distinctive features which the absence of one or other, insignificant perhaps, but familiar plant, is able to establish. Wide heath lands, where no heath is to be seen, remind him of the fact that no species of heath is native to North America. He misses the little purple-rimmed daisy from the green slopes; and we are told that though often planted with care, the flower always dies under the influence of the dry air and bright sun of this climate.

Of the three divisions of the flora the forest region is the most important. The forest is the best security for the fertility of a country, and points out unerringly its general fitness for becoming the home and stage of a higher civilization. Where forests exist, water, food, heat, and good roads are to be found; all that can affect man from without for the development of his higher culture is never so completely gathered together as in well-wooded lands. The history of the old world has furnished clear proofs of this fact, and the new world confirms it no less emphatically. In both the region of the steppes is seen to be a territory, if not absolutely hostile, at least unfavourable, to civilization.

The region of the United States does not extend far enough toward the north to embrace any portions of the Canadian zone of conifers. Its forest region is therefore exclusively that of non-coniferous trees, although conifers are found among them, in the north more than in the south, in the west more than in the east, and on the mountain slopes more than in the plains. And the forests here are unsurpassed for their variety of tree growth; for instance, in the south of New York we find four oaks, three maples, two walnuts, chestnut, beech, ash, elm, tulip tree (*Liriodendron tulipiferum*), sassafras (*Laurus sassafras*), together with many different kinds of pines and firs, cypress, thuja, and juniper; among the latter the red cedar of the Americans (*Juniperus Virginiana*), uniting to form the ground stock of the ordinary forests of the plains and hilly countries; the relics greatly impoverished, it is true, but still easily recognized, of the original virgin forests.

Many forests, however, are seen, which do not deserve the name of virgin or primeval. Cultivation has already made such rapid strides, that the original almost unbroken covering of wood and forest is now cleared in numberless places. Even where it still retains its primitive character, the high wood is no impenetrable thicket, like the tropical jungle overgrown with creeping plants and tree shrubs. It is scarcely denser than our own mountain forests; but it is a unique creation, developed and supporting itself by its own laws. At almost every step young trees are seen springing up from the decaying trunks of fallen veterans, generally of their own kind; perhaps from a cleft in the bark which is less exposed to decay than the wood; or it may be that the new growth is seen rising up close together from the mere shoot just issuing from the germ to medium-sized and tall trees, while all round them lie fallen trunks in every stage of decay. Beginning and end join hand in hand, and every phase of development from germination to mouldering into earth again is seen at once in one unbroken picture.

Here, too, as in Canada, we find the most wondrous autumn colouring. It comes on gradually, and lasts for awhile on every bush and tree. Large groups succeed each other. As the flame dies out from one, it is kindled in another, as if the second had caught the fiery glow from the first. Scarcely has the glory of purple and crimson faded from the red maple, when its neighbour, the sugar-maple, bursts forth into a flame of palest gold; and when this has died down, the oaks clothe themselves in their rich, lasting robe of brown, from the depths of which flash reflections of red, or yellow, or violet. The red maple strikes the first note of the tone picture in August, and the oaks end it in the last half of October and the beginning of November, the snow falling on the brown and crimson leaves before they shew a sign of fading or decay.

But a deathlike silence reigns in the primeval forests. Strange that these woods, so rich in shelter and food, should be so poor in living tenants, and above all, in birds the brightest and most animated of all! In the dense woods the animals met with may be counted; and the observation may be made, at least with regard to the birds, and probably the same is true of squirrels and other small mammals, that they become more numerous in proportion as the wood becomes clearer. In Europe also we find that most singing birds prefer open, thinly wooded groves, nay, even frequented plantations, to more remote and silent woods close at hand. Butterflies, which contribute so much to the animation of the scenery, together with many beetles, bees, flies, and locusts, seek the sun and the meadows, where they may find flowers; and many creatures look for their food from the handiwork of man—the turning of the sod, the sowing of the cornfields, the planting of the fruit trees, combining to prepare a feast for the sparrow, swallow, and field mouse, all of which thrive much better than their kindred, whose living is dependent on the food they find for themselves in uncultivated wastes. But that this should be the case here, where all the riches of virgin nature are found in close proximity to the works of man, may well excite our wonder, and yet the fact is beyond all doubt. The hare and those singing birds which breed in the forests, but seek their food without, have increased considerably with the advance of cultivation; and only the larger mammals which are pursued in the chase, and can only find sufficient shelter and protection in the most extensive forests, especially the elk, deer, beaver, bear, wolf, puma, and lynx, diminish in proportion as the wood is cleared.

The farther we penetrate southward, the more luxuriant are the forests, until they become almost tropical in the moist regions of Louisiana and Florida. The greater part of the northern dwellers in the woods go down toward the south, but are joined by numerous evergreen trees of families of the oak, magnolia, laurel, and holly, together with the poisonous sumach (*Rhus toxicodendron*), the very touch of which is injurious to many men, fragrant, aromatic *Calycanthus* (*C. floridus*), and others. Genuine tropical forms of palms *Chamærops* (*Palmetto, Ch. Sabal*), bamboos (*Arundinaria*), *Yuccas*, and a *Zamia*, with many tropical shrubs, herbs, and creeping plants. Epiphytæ also, such as the greybeard (American moss, *Tillandsia usneoides*), combine to form a scene such as nothing in our eastern forest region resembles. But these luxuriant southern forests are unfortunately of limited extent, for a great part of the southern flat country is swamp overgrown chiefly with a yew-cypress (*Taxodium distichum*), resembling the mimosa. These cypress swamps are sometimes replaced by the everglades of South Florida, which are clothed with a rich tropical vegetation, sedge, and in the extreme west with mangroves (*Rhizophora mangle*); a still larger area is taken up with the monotonous pine barrens, as they are called by the Southerners, covered with trees not unlike those of the fir woods of Germany.

Not without reason are North Carolina and Georgia called the pine state. Few tracts of land of the same extent, in any quarter of the globe, possess such a monotonous tree vegetation, and perhaps nothing resembling is to be seen in any place possessing an equally mild climate. Of course the pine tribe is accordingly represented: the mountain has the Weymouth pines, the prickly pines (*Pinus pungens*), the marsh its marsh pines (*P. serotina*), the fertile lowland its loblolly-bay, or Oldfield pine (*P. tæda*), and the rare smooth pine (*Pinus glabra*); lastly, the dry sandy soil has the true pine barren, the short-leaved *Pinus mitis*, the long-leaved *Pinus Australis*, and the shrub pine, *Pinus inops.* With the exception of the last-mentioned species, which is only thirty feet high, they are all tall, imposing trees, the most numerous being the long-leaved fir, almost exclusively represented in the pine barrens, and one of the noblest types of the whole race. But it is just the largest and most beautiful trees which, for the sake of obtaining their resin, are almost all, without exception, stripped of their bark for about twenty inches above the ground, and cut so deep that the white wood is visible. When the traveller drives by night through one of these pine forests, the white places are seen gleaming through the darkness in endless rows, and the whole scene looks like a vast burial ground full of marble tombstones.

The aspect of the flora changes also, but in a rather different way, as we approach the west. Many kinds of trees which were frequently seen in the east become rarer, and almost every order is less richly represented in its separate species. On the western slopes of the Alleghany Mountains the forest is enriched by the introduction of new forms. In former times, before the woods were cleared and settlements were established, the beech was the representative tree of the high woods of the central and lower part of the Ohio territory; downy aspens (*Populus monilifera, angulata, etc.*), known as cotton-wood, the most numerous western tree, grows to a greater height here than anywhere else on this side of the Mississippi, and the trunks of the plane tree of the west, or American sycamore, the largest of forest trees, are more than thirteen feet in diameter.

Cypress Swamp (*Taxodium distichum*).

The different forest regions of North America have been classified according to their undergrowth. On the eastern slopes of the Alleghanies, *Rhododendreæ*, particularly azaleas and rhododendrons, are the prevalent forms; on the western slope the papaw tree appears; in the valley of the Mississippi, canes and reeds; and in Indiana, different kinds of willow and bilberry are found.

It is not without interest to see how the first settlers judged and appraised these forests, for their classification of the different kinds of woodlands is not altogether without scientific justification. Wherever forest land has to be cleared for the first time, and made available for tillage of any kind, no practical test of its fertility having been previously obtained, it has long been the custom to judge of the soil by the kind of trees which it bears, and even the distribution of taxation is based upon the primitive scale of the three different kinds of forest land. The following plants are said to be distinctive of the richer soils; namely, those of Kentucky and Tennessee: wild cherry (*Cerasus Virginia*), white walnut (*Juglans oblonga*), the different species of ash, the black-jack oak (*Quercus imbricaria*), slippery elm (*Ulmus viscosus*), hackberry (*Celtis occidentalis*), Kentucky coffee tree (*Gymnocladus Canadensis*), the three-horned honey locust (*Gleditschia triacanthos*), and the papaw (*Asimia triloba*). The three latter trees are especially characteristic of a fertile soil. In mountainous regions and along the banks of rivers they are joined, or in some places dispossessed by the overcup white oak (*Quercus microcarpa*), sugar maple (*Acer saccharophorum*), beech, plane, tulip tree, and magnolia. The second-class soils are distinguished by the possession of large trees, as chestnuts, red oak (*Quercus rubra*), quercitron or yellow-barked oak (*Quercus tinctoria*), sassafras persimon (*Diospyros Virginiana*), sweet gum or amber tree (*Liquidambar styraciflua*), and the hairy gum tree (*Nyssa villosa*). The third-class soils, finally, are distinguished by the presence of various oaks, *Quercus rubra*, or red oak, black-jack (*Q. nigra*), chestnut oak (*Q. castanea*), rocky oak (*Q. prinus montano*), firs, and in some places junipers. Generally, too, the poorer soil may be known by the scanty growth of the trees. Even in the swamps, half-swamps, and morasses which are found in such wide areas by the rivers and on the pine barrens of the south, differences in the quality of the soil is shewn by the trees which grow upon it. Certain magnolias (*M. grandiflora* and *tripetala*), a tupelo or sour gum tree (*Nyssa triflora*), the chestnut oak (*Quercus prinus palustris*) are only found where the soil of the swamps near the rivers is good, constantly cool, moist, and shaded. Wherever the same soil is inundated half the year through, and therefore black and boggy, the one-seeded honey-locust and the lyre oak (*Quercus lyrata*) are also found. The swamps in the pine barrens, on the other hand, which generally cover narrow long depressions of the soil, and finally flow out into the river swamps, are overgrown with grey magnolia, red maple, water oak, amber tree, the cottony tupelo tree, and red bay (*Persea carolinensis*).

In the north-western portion of this territory, to the west of the maritime region, marsh woods, reed and turf meadows are especially well represented. Damp meadows, larch and cypress swamps, abound in the valleys. Pines and hemlock spruce are also found in the valleys, and in the lowest depressions the elm is met with. In the river valleys, where the perpetual marsh land is replaced by ground subject to periodic inundations, non-coniferous trees, such as oak, maple, ash, elm, alder, and willow, are found. Higher up grow the firs, yellow birch, and if the soil is very good, the sugar maple. The hill crests overgrown with the last-named tree are known as "maple ridges." The most striking and valuable of all these forest trees are the white pines, found in the smaller pineries and in the better kinds of lowland soil. The sea coast itself presents a strange mixture of coast and alpine plants, *Lathyrus maritimus*, *Potentilla tridentata*, or reindeer moss. Wild rice (*Zizania*) covers whole "rice lakes," and requires neither sowing nor culture, but only reaping for the harvest. One of the characteristic moor plants is the cranberry (*Vaccininm macrocarpum*), and growing beside it, in a turfy soil (*Sphaggnum*) are found the fever trefoil (*Menyanthes trifoliata*), several kinds of andromeda, and the carnivorous sarracenia (*S. purpurea*). The well-known fly traps (*Dionæa muscicapa*), grow in the turf meadows of North Carolina.

The dense woods of the east gradually open out toward the west, and enclose large tracts of treeless ground which are not covered with herbs and grasses. These are the *avant garde* of the prairies, which, beyond the Mississippi, already take up more room than the forests themselves, vast as our idea may be of the great woods. The tree growth of this district is composed of different, often isolated oaks, the so-called post oak, the hickory (*Carya alba* and *tomentoso*), allied forms to the Pekan nut (*Carya olivæformis*), so common in Illinois, whose pleasant fruits form a not unimportant article of commerce.

Asa Gray counted 799 kinds of shrubs and herbs; one-eighth of which belong to the composites, one-tenth to the cyperus or sedge grasses, one-thirteenth to grasses, one-twenty-fourth to leguminous plants, one-twenty-ninth to *Rosaceæ*, a distribution somewhat different from that of the families of the old world.

Among the herbs we find many European weeds, which have followed man across the sea to the New World, and many other herbs and shrubs are either common to Europe and North America, or at least so like European forms, that, especially in the spring, in meadows and shadowy forests it is easy for the European to imagine himself surrounded by old acquaintances. In the former class we may mention the true hemlock, little hemlock, and water hemlock, shepherd's purse, pinks, gillyflowers, trefoil, and tare; and in the latter, anemones, liverwort, buttercup, marigold, larkspur, columbine, and *corydalis;* together with our garden favourite, borage (*dicentra*), barberries, wild roses, ænotheræ, watercresses, violets, pansies, mallows, geraniums, balsams, green sorrel, climbing roses, raspberries, wild strawberries, saxifrage, stinging nettles, hops, myrica, one of which, the water myrtle (*Myrica cerifera*), yields wax; sorrel, knot grass, bilberries and cranberries, honeysuckle, elder-flowers, snowball, wormwood, golden rod, a species of which (*Erigan Canadensis*) has found its way to Europe; comfrey, mint, thyme, lousewort, lion's-mouth, eyebright, henbane, thorn-apple, lilies, *narthecium*, garlic, and asparagus.

The flora of the Atlantic states is much richer than that of California. The relative poverty of the latter country is best shewn by the following list. California has no magnolias, aniseed trees, tulip trees (*Ilicium* and *Liriodendron*)); no papaw, none of the common American barberries, no podophyllum or any of its kindred forms, no white water lilies, no nelumbo, no yellow wood (*Xanthoxylon*), no sumach (*Rhus*), no limes nor robinias, no Kentucky coffee tree (*Cladrastis*), tupelo tree, amber tree (*Liquidambar*), hydrangeas, deutzias, no snowballs; it has few asters or golden rods, no lobelias, and scarcely one bilberry; no epigæa, the ornament of the American spring, no kalmia (American laurel), no maytree (*Clethra*), holly, persimmon (*Diospyrus Virginiana*), catalpa (*Tecoma*); no corresponding form to our sassafras (*Laurus s.*), benzoin (*Laurus benzoin*), hickory, elm, mulberry, beech, chestnut, birch, white thorn, beam or iron-wood tree (*Carpinus*).

The following is the course of the seasons in the northern prairie region (48° N. lat.):—The long severe winter is followed in spring by the wettest season, during which the prairies, parched or covered with snow in the other months, are all in blossom. A dry season begins in the middle of July, and lasts almost without any rain to the end of autumn. During April violent snowstorms fall still sometimes; and in the high woods the trees seldom come into leaf till May, and somewhat later higher up the country it sometimes happens that the forests are not green at the end of May. The flowers of the prairie bloom also in May, but all their wealth of blossom is parched by the end of June. The period of vegetation for herbs ends with July. In the woods and on the river banks the foliage continues till October. In November the Missouri freezes, and from that time the snow lies on the ground till March.

Level prairies are rarely seen; they are chiefly found to the south and west of Lake Michigan, and in the spring districts of the Illinois and the Wabash rivers. To the west the rolling prairie is so much more frequent, that a level tract of prairie is scarcely to be found in Iowa. The depressions are generally moist and swampy; and where the difference o level is very great, the result is the origin of running water, with it the formation of steep banks and densely wooded bottom.

The plant growth of the prairies consists chiefly of herbs. Trees and shrubs are only seen under special circumstances, and then only isolated or in separate groups. The meadow type is the universal characteristic of the prairie. In the lower parts the grass grows high; the higher and drier is the prairie, the finer is the grass, and the closer the turf. This fine grass of the high prairies consists chiefly of *Sesleria*, or buffalo grass; *Bouteloua*, or muskit grass; and *Festuca*, or bunch grass. These are all very succulent grasses, and are of great importance in dry districts from their capability of preserving their nutritious juices in the dry season and in winter. The grasses prevail everywhere in the prairies of the east, in contrast to those of the south-west, where they are lost as it were among the herbaceous plants and shrubs. The best represented of the prairie herbs are the families of the compositæ and the leguminous plants, and in the former the groups of asters and sunflowers are more numerous than all others. The tree primroses (*Ænothera*) are distinguished by their large bright-coloured blossoms.

The herbs of the prairies are generally tall, large, and often resinous growths, with large thick leaves and projecting flowers. Some of them are well known, at least by name. The compass plant (*Silphium laciniatum*) is said to turn the edges of its wide thick root leaves true north and south. These leaves are often two feet in length. Travellers in the prairie, we are told, shape their course with confidence by the guidance of this compass, conjured up by the effect of the sunlight. Another silphium (*S. perfoliatum*) forms by the shape of its leaves a large drinking cup. The turban flower (*Pentalostemon*), with its large white and purple clusters of flowers, is one of the most beautiful ornaments of the prairie. A few of the sunflowers, especially helianthemum rigidum, turn their flowers to the sun from morning to evening. A very characteristic form is the cacalia (*C. tuberosa*), with its large, dark-green leaves, resembling those of the pisang. With these we find among the colouring flowering plants the prairie pea (*Astragalus Mexicanus*), the wild hyacinth (*Scylla fraseri*), poppy, mallow (*Malva papanera*), tradeskantia, a rose-coloured mimosa (*Schrankia*), thistle poppy (*Argemone Mexicana*), red zinnias, blue larkspur, and salvias. Red, blue, and yellow, of the most brilliant tints, are found among these blossoms; the first dawn of spring brings a flush of peach colour, which passes next into blue, and afterwards to yellow. To the untrained eye of the foreigner the vidid scarlet blossoms of the summer and autumn are the most striking, as he is accustomed to these colours by the poppy and adonis among the corn, but not in meadow-lands. A singular effect in colour is produced by the feathery leaves of the pulse plants, which are generally of a shadowy grey, so that they impart a peculiar tint to the plain; and it is a wonderful sight when a light wind stirs the leaves of the numerous kinds of *Astralagus, Psoralea, Baptisia*, and the beautiful amorpha (*A. canesceus*), and reveals the silvery gleam of the down covering the under side of the leaves.

In about 100° longitude the prairie changes by the gradual disappearance of the grasses and meadow herbs, and the appearance of a distinct and characteristic heath flora, into the steppes or plains of the south-west. The latter are distinguished by a preponderance of plants of a dry climate, abounding in sudden changes, and contain also many of the saltwort tribe. The forest growth is restricted to within still narrower limits than that of the prairies, and there is no dense wood to be found upon the mountains lower than 9,000 feet above the sea level. Composite and leguminous plants are here also the families possessing the greatest numbers of different species, but although the families are sometimes the same, they are generally represented by very different species. The whole vegetation bears the impress of great uniformity, not to say monotony, the latter being especially produced by the decided preponderance of the prevailing species, which decide the size and colour of the flora as a whole. There are certainly distinctions in the vegetation of the steppes which separate by a wide divergence the northern from the southern section of the vast territory; but the name, "Kingdom of artemisias and chenopods" (wormwood and goosefoot), given by Watson to the northern division of the great basin, may be applied to all the different and more or less sharply defined aspects of the North American steppes. Sage brush (*Artemisia tridentata*), etc., is so far characteristic and frequent in these steppes, that the name by which they are called in popular language is sage plains, or artemisia plains. In number of individual species next to the sage brush come the different kinds of greasewood, a low, obscure, and branching shrub (*Obione*).

Connected with the steppes by numerous transitions, and locally surrounded by them, the deserts appear as their final and most barren form. The gradations by which the steppes are led to assume the desert form are threefold: 1st, steppes, treeless plains covered with grass;* 2nd, semi-desert, treeless, with little or no grass, but overgrown with low shrubs (wormwood, orache, aplopappus)—this form is found in Nevada, Utah, Wyoming, north-western Texas, West Indian territory, New Mexico; 3rd, true desert, with exceedingly scanty vegetation, some parts being absolutely barren; found in Mohave Desert in Calfornia, Gila Desert in the south-west of Arizona, Painted Desert in the north of Arizona and the south of Utah. Only the three last-named true deserts are so utterly destitute of water that they contain no oasis whatever capable of cultivation, the first and second group being rich in oases formed by the mountain chains which intersect, and the streams which flow through them. On the other hand, tracts of perfect desert type are found scattered through the prairies and semi-deserts. As to the position of the true desert, it may be assumed, broadly speaking—for the territory situated before the Rocky Mountains in Colorado, and the Sierra Nevada of California, and extending southward to the Mexican frontier—that all territory below 3000 feet above the level of the sea belongs to the true desert; the semi-deserts being found between this altitude and 4,500 feet. Wherever the ground rises higher than this, it is more and more covered with vegetation, and at 6,600 to 7,500 feet extensive forests, rich pasture grounds, and numerous springs of water are found.

The most important of the North American deserts is the Mohave Desert, which occupies an area of 41,400 square miles. Within the desert regions we must also include considerable portions of the numerous basins with no outlet which surround the high plateau of the interior in Colorado, Utah, Nevada, New Mexico, California, Texas, and Arigona. One of the most extensive among them is the Great Salt Lake Desert, lying to the west and north of the Salt Lake, where, between Granite Rock and the Goshut Mountains, extends a tract of twenty miles wide, without a single blade of grass, and covered with a thin crust of salt, as with a fresh carpet of new-fallen snow. Other sections of the desert region are the Sandstone Plateau, of the Llana Estacado, in Texas; the Gila Desert and Painted Desert on the Gila river; Colorado Desert, on the lower Colorado; Ralstan Desert and Lava Fields on the eastern slopes of Silver Peak range, the lower parts of Columbia Plains, and the country round the lakes of Tular.

"For a day and a night," says a traveller, "the train whizzed through the barren steppe of Cheyenne to the basin of the Great Salt Lake, but except for a few oases of succulent grasses and green willows and poplars, its characteristics of rock and firs remain the same, and only change in appearance with

* Nebraska, Dacota, West Kansas, East Colorado.

the changing colouring of the scanty vegetal covering, as it grows more closely or thinly. An apparently slight variation; but in this scenery, where all is monotony both of colours and forms, every smallest detail is significant. The vegetation is composed in its essential characteristics of the same plants as that of the high prairies: dry grasses, woody lupins, artemisias, purslain, saltworts, which generally assume the form of low shrubs, dry, grey, or yellowish green plants, bearing but few leaves. Flowers, with long scarlet blossoms; œnotheræ, with drooping flowers one or two inches in length; fields of wild rye, and sometimes juniper bushes, contribute the darker shades of colour. Occasionally the whole colouring inclines to grey or yellow; and then the dry but tolerably close grass appears more and more in the form of isolated semi-circular patches, the yellow sand visible on every side of them. Even this scattered vegetation becomes scarcer by degrees, until it disappears altogether, and leaves behind it a waste of utter desolation. For a time the desert stretches out towards the horizon, and then again a flush of green is visible, tufts of wild rye or bushes of artemisia, and perhaps in some deep, narrow cleft a streamlet or tiny watercourse flows along between low and meagre willows. In the deserts of the south are seen cactus, agave, and other plants which are more or less dependent on moisture, but yet have something of tropical luxuriance and American plant formation.

The coast country of Upper California rises uniformly from the Pacific Ocean to the crest of the Sierras. South of the mouth of the Oregon the fir trees cease along the coast, and forest scenery gradually disappears from the plain, the hills, and the lower mountain slopes. In places such as these no great forest rises from the plain, and indeed not many trees are found beyond San Francisco, until at last the Californian peninsula assumes such a different appearance, that we are compelled to describe it as belonging to the prairie region. As a rule, nothing is seen in the coast districts but low, stunted bushes, of which the glossy or hairy nature of the foliage already shews their capability of resisting the summer drought. The most diversified cactus forms often accompany these almost impenetrable shrubs. Also upon the lower slopes of the high chains these formations are frequently observed; the meadows by which they are occasionally varied resemble those of southern Europe both by the variety of shrubs which compose them, and by the sudden contrasts of beautiful and luxuriant flowers and barren desolation which follow each other so quickly according to the phases of vegetation. Along the sea coasts the meadows often become rich pasture lands by the abundance of clover and other nutritious herbs which they produce, but in the interior the herbs are replaced by shrubs and annual grasses. When Froebel, on his journey to Las Angelos (34° N. lat.), had crossed the mountain passes from the side of the prairies, he came upon a growth of a kind of oats, which was so abundant that the grains, after ripening, covered the ground. This grass and a variety of annual clover extended over measureless plains, and its seeds constituted almost the sole nourishment of a large cattle station for many months of the year.

In sailing up the Sacramento from the coast, the traveller perceives a wide alluvial plain, open, and resembling a natural park, with a few scattered coppices of oak. The river flows through the plain, and inundates it in wet seasons. Besides the evergreen and periodically blooming oaks, the coppices contain the Californian laurel and a few isolated varieties of ash and horse-chestnut, while along the river-side are found willow, plane, and poplar.

Ascending the mountain chain (33° N. lat.) we reach the lower forest region at about 1,900 feet above the sea level, and at 4,500 the region of the Wellingtonias. The former presents in South California only meagre oaks and conifers, and it is not until we reach the central districts beyond 36° N. lat. that the growth of the Californian giant trees attains its grand proportions. In the conifer forests of California, twenty-eight varieties, and more than half of these exclusive forms, have been found up to the present time, and these are especially distinguished by their great size, the greatest wonder in this respect being the Californian mammoth tree, or Wellingtonia (*Sequoia gigantea*).

Mammoth Tree (*Sequoia gigantea*).

These giant trees are always found growing among other conifers, and there are now eight groves discovered in which they exist. The highest known tree is the so-called keystone state of the Calavera Grove, and measures forty-two feet in diameter, and rather more than three hundred in height. An examination of many of the fallen trees gives rise to the belief that they were once more than 375 feet high, and even if this were so, they would not be unique of their kind, for several eucalypti in Australia are known to be of that height, and the tallest of the Australian giants, according to the measurement of Prof. F. Müller, the government botanist, are 450 feet high, and so attain to the level of the highest edifices raised by the hand of man, the Cathedral of Cologne and the Egyptian Pyramids. The age of one of the ancient giants of the Californian forests, the "mammoth of the forest," is estimated at 3,400 years, a number which seems so incredible that we hesitate involuntarily to repeat it. And yet there is little likelihood of error, for the annual rings of the trunk indicate its antiquity with sufficient clearness. The venerable age of the Wellingtonia extends without question farther back than the birth of our Lord, farther back than the period at which many more great historic names first appeared on the page of history. Its youth was passed in the days when Moses lived, and Solomon built the temple in Jerusalem. The appearance of the lofty trunk, which tapers towards the summit far less than is the case with other trees, has been aptly compared to pale brown columns standing here and there in the forest. The branches are not so picturesque as those of other coniferæ, and have something massive and solid about them. Very often the branches, which begin to grow out of the trunk at about eighty or ninety feet from the ground, are as large as full-grown trees. The crests have generally disappeared long since, blown away centuries ago, it may be, by the stormy wind as it raged through the mighty forest, and many Wellingtonias have been scorched in fearful conflagrations, and so lost much of their beauty. Others have been felled by the hand of man, stripped of their bark, or otherwise injured, so that in the case of the

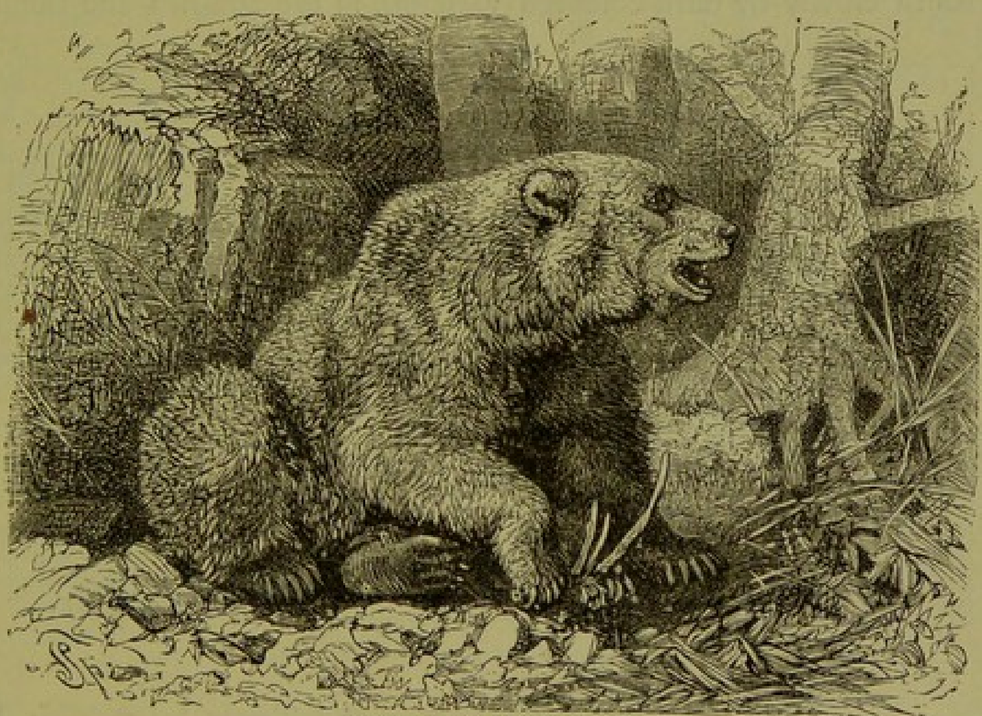
Mariposa Grove, the only one which is still in a state of perfect preservation, and in the far-famed Yosemite Valley, situated not far distant, it has been necessary to put an end to the reckless damage by declaring the ground to be State property, and converting it into a national park for the advantage and recreation of the public.

"Slowly rides our calvacade," says V. Hesse-Wartegg, "for some seven miles through the noble forest, gazing in admiration at the gigantic Wellingtonias, which, to the number of about six hundred, appeared sometimes to be scattered far apart, and sometimes close together. Occasionally our path lay right through a half-burnt mammoth tree, through which we passed erect in our saddles, as if through some tall city gates. The larger trees have names displayed in letters of gold upon their trunks. How glorious yonder stretch of meadow-land nestling in the well-wooded valley! how proudly the comrades of the forest giants rear their slender stems, often 150 or even 250 feet high; reedwood (*Sequoia sempervirens*), pitch pine (*Pinus ponderosa*), sugar pine (*Pinus lambertiana*), with its stores of sweet gum; the Douglas fir (*Abies Douglasii*), the giant pine (*Picea grandis*), a cedar (*Librocedrus decurrens*), and others whose tall crests rustle above us in the morning breeze! The distant views of the thickly wooded mountain heights are exquisitely picturesque, and we are favoured with the most splendid weather which can be imagined. Here and there, like clear flames rising from the ground, shine the flowers of the slender snow plant (*Sarcodes sanguinea*), as if cut out of bright red wax, among the giant cones, often twelve inches long, which have fallen from the trees. Even the withered branches of the soaring pines are veiled in pale-green mosses, as if nature would have the beauty of the forest scene marred by no touch of barrenness. The song of birds rarely breaks the profound stillness, although the forests, lying 1,500 feet below, are vocal with their merry madrigals."

A safe and well-kept mountain road leads us to the famous Yosemite Valley, with its rocks and walls of granite 3,000 feet in height, its waterfalls dashing down from twelve to fifteen feet overhead, and all its other natural marvels. It is true that the scene can boast of no Alpine glaciers or snow-peaks, no lake mirrors in its blue waters, fair cities, picturesque mountains, or green landscape, no Rhineland scenery, with castle and storied fortress, no grey cities, rich with the civilisation of a thousand years. Before us lies the wild grandeur of nature. And as Fenimore Cooper justly observes, it is the lack of finish in the North American landscape, and the greater number of works of the hand of man in the European, which constitute the difference between the scenery of the Old and the New World. And the American does not allow his weary eyes to be oppressed as if by a heavy load by the endless succession of the wild or lovely scenes of his continent. As he wanders beside the wide rivers of his native country, his mind is always busy with the future of the scene before him. Instead of looking down upon some English valley which has borne the same aspect for centuries past, inhabited by noblemen and yeomen, whose homesteads have descended for many a generation in unbroken line, without a change of name, whose fields, always tilled in the same manner, have never changed their boundary lines from time immemorial, he sees before him a valley teeming with luxuriant vegetation, laden beyond measure like a harvest waggon, a fresh virgin land, where as yet no foot has trodden the soil, and he sees in thought the villages which will soon rise along the hillsides, he hears the axe echoing through the forest, and conjures up the mills, bridges, canals, and railways, which are soon to rise upon the banks or span the waters of the river now framed with groves of lofty trees or tracks of waving sedge. And is he wrong? Has not the productiveness of the Californian soil attained to an undreamt-of development since the discovery of its mineral treasures increased the population of its cities? and does it not now assume proportions surpassing even what might have been expected from the proverbially large profits of mining enterprise? The vine growths of Europe have taken root within its borders; figs, peaches, apricots, mulberries, olives, citrons, and oranges ripen to rare perfection;

walnuts, almonds, pomegranates, and even tea, are successfully cultivated. In many parts of the country cereals and different kinds of fodder yield rich returns, as for the year 1873-74, according to the official estimates of the returns, the wheat harvest was valued at £9,550,000, that of other cereals at £2,000,000, wine at £850,000; and for that year only the returns obtained from wool were recorded as £2,250,000.

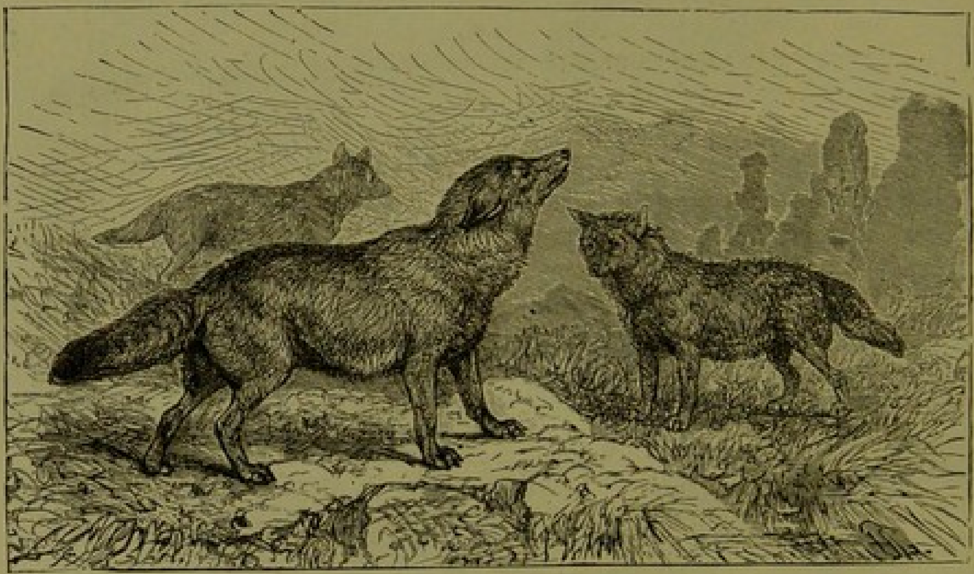
The fauna of the United States is comparatively poor, and if this poverty is partly owing to the formation of the land and to the climate, it is certain that the geological development of the country, especially in its last action during the glacial age, must be recognised as an important factor in producing the present state of affairs. The same causes which impress upon the climates of widely separated lands certain common features, and which have allowed many plants to wander from the gulf to the great lakes, and even from the Atlantic to the Pacific Ocean, have also created the less diversified and less sharply defined regions of the distribution of animals. Of especial importance



Grizzly Bear (*Ursus ferox*).

in this respect are the direction and extent of the Rocky Mountains. They might have formed a sharp limitation to the dispersion of animal life, if their chain were as massive as that of the Himalayas, or even as that of South American Andes. But as valleys and plateaus of moderate height and mild climate penetrate the range on both sides, and as in the highest and most unbroken parts there are paths by which most animals can easily cross the mountains in the summer, the chain, although it possesses many isolated peaks of great height, is on the whole unimportant as a means of separation between the animal life on either side. It is not the mountain range which forms the distinctive barrier between the two great subdivisions of the distribution of animals, but the imperfectly defined line of which we have recently spoken in treating of the distribution of plants, and which generally coincides, or nearly so, with the 100° meridian of longitude, separating the western steppes from the meadow and forest land of the east. To the east of this line extends the sub-region of the Alleghanies; to the west, that of the Rocky Mountains, and the latter joins in the far east the sub-region of California. The northern and southern limits of these sub-regions are determined, as they meet respectively the Canadian and Mexican faunas, less by the formation of the ground than by climatic peculiarities.

The following mammals deserve our principal attention, either as specially characterising the fauna of the United States, or because of their importance in reference to man. Bears, the largest of the carnivorous animals, are found distributed over the whole country. The black, or American bear (*Ursus Americanus*), is found in every part except in California; a brown bear belongs to the Missouri region, and the grizzly bear (*Ursus ferox*), the strongest and most dangerous of the American wild beasts, inhabits the north-western districts, and is especially numerous in California. There are two varieties of racoons, an eastern and western. Wolves (two genera and several species) are dispersed throughout the whole region. The common wolf is represented in the south chiefly by dark-coloured varieties, in the prairies and the desert



PRAIRIE WOLF, OR COYOTE (*Canis latrans*).

regions by whitish yellow, and in Arkansas and Texas by reddish brown specimens. The prairie wolf, or coyote (*Canis latrans*), something between a wolf and a jackal, belongs to the west and south-west. No animal is so hated by the prairie hunters as this thievish beast. "When we spent the night in the prairie," says a traveller through these countries, "we used to hear at dusk the short staccato barking of a solitary coyote. That was the signal for the gathering. Soon other voices replied, and within a short time the prairie is filled with the loudest and most appalling howling possible to be imagined. Each one seems trying to howl down his companions, and every fresh arrival is greeted with the same music. They seldom venture within the camp, and then only at daybreak, when they creep underneath the waggons, steal everything eatable, even if it is only the portmanteau upon which the sleeper's head is resting, and run away without attacking human beings. Strangely enough the ear-splitting howling is a welcome sound to trappers and hunters, for as long as it continues there is no danger to be apprehended from the presence of Indians, while as soon as it ceases it is certain that the red men are lurking near." There are seven varieties of foxes. The eastern fox (*Vulpes fulvus*) is as sly as our own reynard, and as it is always on the watch for the farmer's poultry, it is, in its turn, relentlessly hunted down. There are nine weasels, and two martens; the latter are found right through the northern part of the region. The ferret (*Bassaris*) is a Texan and Californian beast of prey. The fish otters are represented by two varieties; one in the east and the interior, and another on the Pacific coast district; the sea otter (*Enhydris*) is Californian. The wolverene (*Gulo luscus*) belongs chiefly to the Canadian region, but is found in single instances in the northern parts of the steppes, in Maine, and Massachusetts. The badger (*Taxidea Americana*) belongs to the west, and is not found eastward of the Mississippi; its skin is a valuable fur. Of the five polecats, four belong to the west, but the most widely distributed (*Mephitis mephitica*) is that found in the east and in the south.

Two families of feline carnivora are represented. The cougar, or puma (*Felis concolor*), also called American lion, is found distributed through the whole region from 55° N. lat. to 54° S. lat. The jaguar, or ounce (*Felis onca*) is found in the west of Texas the ocelot (*F. pardalis*) probably in the north of Texas; the two small wild cats, *Eyra* and *Yaguarundi*, in Texas. Several varieties of lynx, also known as wild cats by the Americans, inhabit North America, from the tropics to 60° N. lat. Opossums are represented in two varieties; in the east and the interior by *Didelphis Virginiana*, and in the south-west by *D. Californica*. The largest American rodent, the beaver (*Castor Canadensis*), was once one of the most widely distributed; at the present time its home is restricted to the east of the Mississippi and the less frequented and populous regions, which are, however, becoming more and more limited in number and extent. The same fate is shared by the musk rat (*Fiber zibethicus*), which is found throughout the whole territory. Among the rodentia thirteen kinds of hares, two moles, two prairie dogs (*Cynomis*); and on the east and west of the Rocky Mountains respectively, one porcupine (*Erethizon*). Squirrels, especially the black variety (*Sciurus niger*), multiply so rapidly as to become a pest to the agriculturist; and pouched rats, gophers, prairie squirrels (*Saccomys* and *Tamias*) like the European mole, work great havoc among the crops. The armadillo, the only specimen of the edentata which is found in North America, once the home of giant members of this family, spreads from Mexico to the west of Texas. Sea lions frequent the west coast, which is also the exclusive home of two species of seals (*Halicyon* and *Eumetopias*). Of the multungula, only the peccari, or Mexican hog (*Dicotyles torquatus*) is found in the lower districts of Texas and Arkansas. Ruminants are on the whole represented by forms very nearly corresponding to old-world types. The mountains of the west have the white or mountain goat (*Capra montana*), and the horned sheep (*Ovis montana*), together with the prong-horn (*Antilocapra Americana*), an animal between deer and cavicorn genus. Deer are represented in five varieties, the most widely distributed being the Virginia stag (*Cervus Virginianus*) found in all parts of the United States, with the exception of the Pacific territory; together with this species we find the large-eared stag (*C. macrotis*) and the white-tailed stag (*C. leucurus*) in the western districts, both being inhabitants of the steppes to the east of the Rocky Mountains. The Richardson stag is found in the Pacific states, where it is distributed from southern California to Alaska. The largest of the American stags, the Canadian elk, or waipiti (*C. Canadensis*), was at one time probably found in all the temperate districts of the United States, but it is now restricted to the thinly populated countries of the west, and is only found on the east of the Missouri in a narrow tract of the Alleghany Mountains. In the north, up to lat. 56° or 57°, it is replaced by the American moose-deer, the original form of the French elk (*Alces Americanus*), but this stately creature is only found in any considerable numbers in the uncivilized districts of Maine and Minnesota. The reindeer, in its southern form (*Rangifer cariban*), extends as far down as Maine and the northern shores of the great lakes. The bison in America, commonly but erroneously called buffalo (*Bison Americanus*), once dispersed through the whole eastern part of the states as far as the Rocky Mountains, is still found in certain localities, but since the establishment of European settlements is gradually retreating westward, and is now, by the opening of the railway and emigrant tracks, restricted to two centres of distribution, one of which is situated between Lake Athabasca and lat. 45° N., and the other between 42° and 32° N. lat.; both centres occupying scarcely ten degrees of longitude at the foot of the Rocky Mountains.

The buffalo herds assemble during the winter in the wooded mountain regions, and in the summer repair to the plains; their wanderings extending from Canada to the coast districts of the Gulf of Mexico, and from the Missouri to the Rocky Mountains. We do not possess such accurate information as could be wished respecting these periodical wanderings, but it is certain that they are intimately connected with the state of the fodder supply. If there is abundance of food to be had, they assemble first in small herds of ten to fifty head of cattle, which gradually are increased to vast proportions, and become immense herds, equalling in number the troups of gnus, white-faced antelopes, quaggas, and ostriches of South Africa. Wherever they have established themselves, they wander to and fro with great regularity between the succulent pasture lands and the rivers, whither they repair to drink or bathe in the cool waters. It is during these wanderings that they tread down the paths known as buffalo tracks, so familiar to all who have travelled through countries which they frequent. But man has greatly thinned the ranks of these herds, which within the last few decades might have been counted by hundreds of thousands, if not by millions; and instead of the hunters of Colorado going out as in former times to procure a dish of buffalo tongues, the inhabitants now carry on a lucrative trade by going in search of the buffalo skeletons, which lie bleaching in the sun, and selling them at the railway stations.

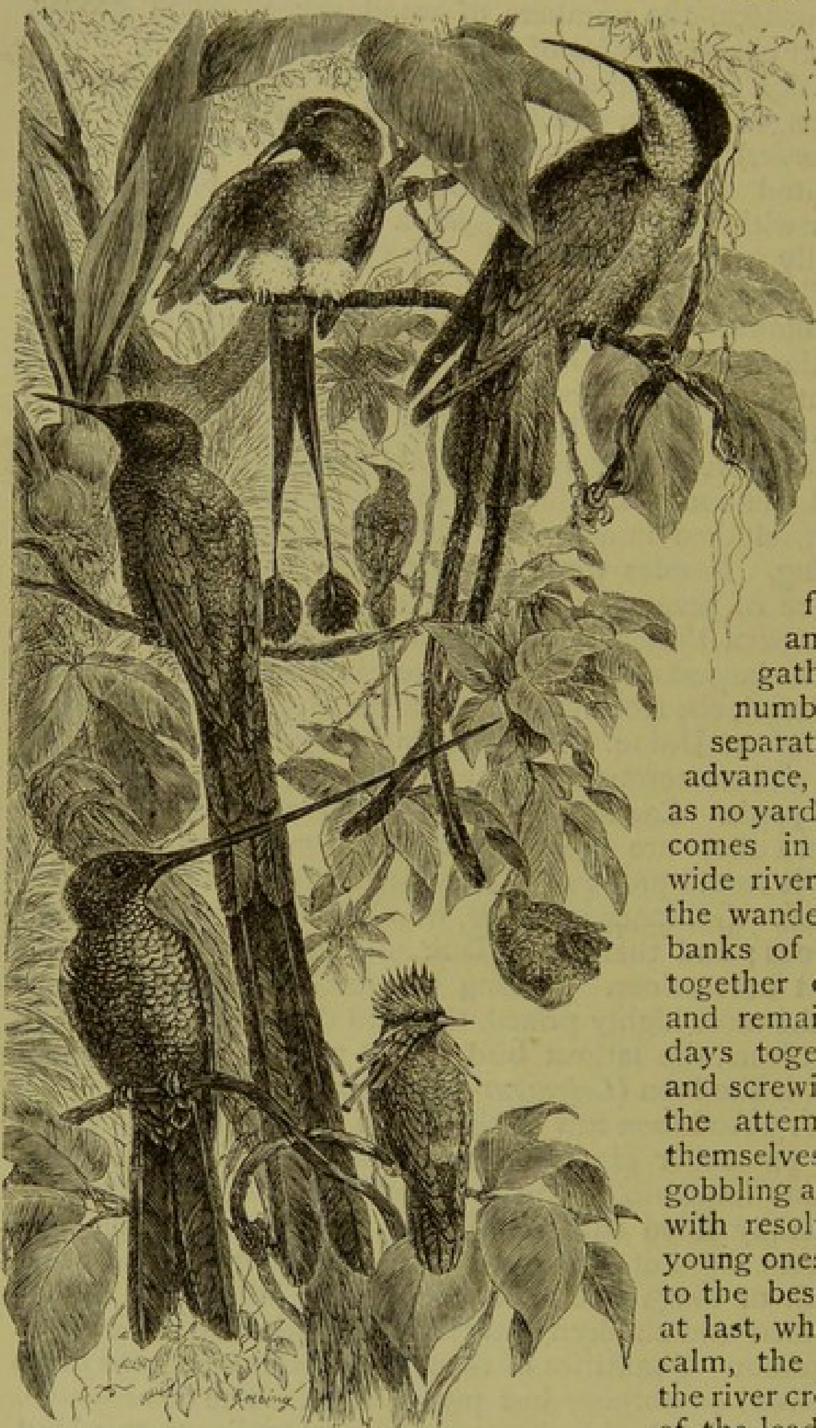
One of the most interesting places of amusement in the neighbourhood of San Francisco is the Cliff House, near the Golden Gate, and close to the seaside. To drive thither during the moonlit nights is the very incarnation of romance. From the wide verandah of Cliff House, a splendid view may be obtained of the family life of a colony of sea lions (*Otaria stellari*), these strange denizens of the ocean having taken up their abode upon a number of bare and jagged rocky islands. The place literally swarms with seals and their kindred forms, the sea lions, whose plaintive whining bark often overpowers the roaring of the surf upon the rocks. The larger animals, which weigh probably nearly a ton, are like the patriarchs of the colony; they keep the younger ones in good order, and live on the best of terms with the long-legged sea birds, who walk to and fro among them with the greatest coolness. The seals either drag their enormous bodies helplessly and awkwardly along the rocks, or enjoy a quiet nap, or sit up comfortably and scratch their heads with their large fins. When one of the great sea lions lies down with head erect and broad shoulders exposed to view, its resemblance to the king of beasts is said to become distinctly visible. It is extremely amusing to watch the ways and manners of these creatures. In some places the old ones are seen playing with their young, which measure scarcely twenty-four inches long; others are trying hard, by the help of their clumsy, cat-like paws, to climb out of the water up upon the rocks, which they find a work of immense difficulty; others, again, throw themselves with a splash from the rocks into the water, which rises up above them in columns of spray, or swim about in the waves. It is an inexhaustible source of pleasure to visit the Cliff House, and see the sight, which has, perhaps, no counterpart in the whole world. The colony of sea lions, close to the very gates of the town, is the pride of every citizen of the state. Unmolested, the animals enjoy their freedom on the so-called seal rocks. No one is allowed to kill them or interfere with them in any way, for the Californian State protects them from all molestation by heavy penalties.

This region possesses thirty-nine exclusive genera of birds, exclusive of numerous migrants, which pass through every autumn on their way to their winter quarters in southern Mexico and the West Indies. Compared with the Old World, the families of the vultures, tanagras, calibris, starlings (*Icteridæ*), and screamers (*Clamatores*), are especially rich in representatives, while in comparison to South America, the numbers of woodpeckers, wood grouse, and turkeys form the chief characteristics of the bird world.

The eastern subdivision is distinguished by its almost exclusive possession of the famous passenger pigeon, of blue slate colour, with reddish grey breast (*Ectopistos migratorius*), and the prairie fowl (*Cupidoma cupiao*). The only parrot of the United States (*Conurus Carolinensis*) is found in the Southern States, together with the ani (*Crotophaga*), a bird allied to the cuckoo tribe, and found principally in South America. The turkey cock (*Meleagris gallopavo*) and the "quail" of North America (*Ortyx Virginianus*) belong to this region, as do also the following varieties, so eagerly sought for in our collections: the black and yellow rice bird (*Dolichonus oryzivorus*), the best singer of the north; the brilliant boat-tail (*Calcophanes quiscalus*), with its colouring of violet and purple shading to bronze brown; the bright orange and black Baltimore bird (*Icterus Baltimore*), the scarlet cardinal (*Cardinalis Virginianus*), and lastly, more toward the south, the famous mocking bird (*Mimus polyglottus*), a kind of thrush, clothed in a modest suit of brown and white, but noted for its lovely singing. Besides these extraordinary birds, the scene is animated by the presence of several other sweet singers, among them the oriole (*Pirole icterus*), a dozen thrushes, blue birds (*Siala*), and the cat bird (*Mimus Carolinensis*). The largest of the birds of prey is the white-headed sea eagle (*Haliætus leucocephalus*), six feet in width from the tips of the expanded wings, the national arms of the Union. It lives principally on fish; while the buzzards, hawks, falcons, and numerous owls pay their court, as they do among ourselves, to the poultry yards. Carrion vultures (*Cathartus atrates*) are only found in the south, where they are protected by law on account of their supposed usefulness, but it would probably be far better to shoot the unclean birds, and bury the carrion. Gallinaceous birds, wood grouse, red grouse, and black grouse, are numerous; and there is no lack of marsh and water fowl, such as ducks, snipe, and beccassines. Among the ducks, the canvas back (*Fuligula vallisneria*) is the most highly prized, the wild duck (*Aix sponsa*) the most beautiful; among divers, the largest bird of the region, and one much sought after in the chase, is the loon (*Colymbus torquatus*).

In the autumn of 1813, Audubon saw at the confluence of the Salt River and the Ohio a flight of passenger pigeons, which seemed to him the largest he had ever seen. It was impossible even to count the passing flocks (or groups), the air was literally filled with them, and the afternoon sun was obscured as it is during an eclipse of the moon. The excrement fell in masses like snow, and the rush of wings exercised a soporific influence. Along the shores of the Ohio, men and children gathered in crowds and shot incessantly at the stranger guests. Quantities of them were destroyed; for more than a week the people lived on nothing but pigeon flesh. The atmosphere, during their passage, was saturated with the evaporation peculiar to this kind of pigeon. It has been calculated that such flights probably contain one or more thousand million birds, and it is easy to see what immense quantities of grain must be devoured by these uninvited intruders, and what devastation is wrought in the forests selected by them for sleeping or breeding places. Many trees, with trunks nearly twenty-four inches in diameter, were broken short off near the ground by the weight of the birds falling upon them;

and the branches of the tallest and strongest were thrown down as if a whirlwind had raged through the forest. Vain were the united efforts of eagles, vultures, wolves, foxes, lynxes, panthers, bears, racoons, opossums, and man himself, to annihilate the armies of these invaders, which, by their numbers rivalled the swarms of locusts.



HUMMING BIRDS. (About half the natural size.)

The turkey finds his home in the forests of the east, especially those which contain vines and pecan nuts; but towards the month of October, when few seeds have fallen from the trees, they wander away to the valley of the Ohio and the Mississippi. The males assemble in companies of ten to a hundred birds, and seek their food alone; the females and half-grown young ones gather together in equal numbers, and follow the path separately. In this way they advance, always on foot, so long as no yard-dog or other quadruped comes in among them, and no wide river bars their way. When the wandering troup come to the banks of a river, they assemble together on the highest ground, and remain there sometimes for days together, as if deliberating and screwing up their courage for the attempt. The males swell themselves out and strut about, gobbling as if to inspire themselves with resolution, and the hens and young ones anxiously imitate them to the best of their powers, until at last, when the weather is very calm, the venture is risked, and the river crossed. One single cluck of the leader gives the signal for the flight. The old birds find no difficulty in the crossing, but if the river is three to six thousand feet wide, the younger and weaker birds often fall into the water, and are forced to attempt to finish their journey by swimming.

Eleven kinds of humming birds (*Colibris*) are known in the United States, only one of which (*Trochilus colibris*) is dispersed through the whole region east of the Rocky Mountains. This bird is one of the most widely distributed species, and is found from Brazil to 57° N. lat. In the west the *Selasphorus platycercus* is found throughout a wide region from Mexico to Oregon and Wyoming, and from the foot of the Rocky Mountains up to the outskirts of the forest region. The rest are confined to the southern districts, and chiefly to the frontier land near Mexico.

The humming birds, or colibris, belong exclusively to America, and more than any other family are characteristic of the American continent. They are found there wherever the earth is capable of producing blossoms of flowers, from Sitka to Cape Horn. The North American humming bird has been observed in Labrador, a species which represents it in the west is frequently seen in Oregon, and the apparently fragile and weakly bird is also found in Terra del Fuego. And they have not only a wide surface distribution, but extend upward to the great chain of the Andes, where they are seen fluttering on the limits of the snow line at a height between twelve and fifteen thousand feet above the sea level. They hover above the craters of both active and extinct volcanoes, where scarcely another higher vertebrate animal strays. The explorer, spurred on to ascend those desolate heights by the love of science, and surrounded by whirling snow and beating hail, has seen the little creature sitting over her brood, when he fancied himself the only living being except the condor to be found in these solitudes. Out of the 390 species mentioned by Wallace, 275 are found in tropical America, 100 (partly of the same kinds) in the tropical lands of North America, fifteen in the temperate southern belt, and fifteen in the Antilles. But it would be erroneous to imagine that the forest of the lowlands, where plant life attains its highest development, is the true paradise of the humming bird; on the contrary, the greatest number of colibris are found in mountainous regions, where the great diversity of the beautiful order is to be seen to great advantage. No single species remains from one year's end to another in the same locality, but all wander to and fro, as the time of year, or at least as the flowering season, makes it necessary; indeed, with the exception of their breeding time, they are constantly wandering about. The same kinds which are natives of temperate lands have their regular pilgrimages, and appear and disappear with the same punctuality as the swallows in our own country. The movements of the humming bird, as is probably the case with those of the hornet, are exceedingly rapid and abrupt; their flutter and sudden alighting gives them some resemblance to a butterfly common in Central Europe (*Macroglossa stellatarum*). The food of these brilliant little birds, some of which are as large as a swallow, and shine with gorgeous metallic colouring, consists principally of insects and the nectar of flowers.

The central region, or region of the Rocky Mountains, has also its own peculiar species of birds, both constant and migrant—the latter cross the country flying southward—but there are no forms among them deserving of any especial attention. A water angel, a wren, a few crows, and red grouse, belong to the constant birds; while the principal birds of passage are the thrush, finch, a titmouse, and the Bohemian waxwing. The Californian subdivision is distinguished by its crested quail (*Lophortyx Californicus*), mountain quail (*Oreorty pictus*), a red grouse (*Pidiocætus columbianus*), and a blue crow allied to the nut-cracker (*Gymnokitta cyanocephala*).

Certain peculiarities of the Californian fauna are intimately connected with its climatic conditions. The greater number of tropical bird forms, and such as remain the whole year through without wandering within the boundaries of the region, depends upon the mildness of the climate; and the relatively large number of lizards, when compared with those of the Atlantic states, together with the comparative scarcity of turtles and frogs, is due to the dryness of the atmosphere. This circumstance creates a superficial resemblance to other countries possessing the same peculiarities of climate; for instance, to the Mediterranean region. Even the generally rocky coast of California, when contrasted with the sandy and marshy shores of the Atlantic coast of North America, exhibits a similar resemblance, which extends also to the fish and crustaceæ of the coast. Finally, the district has fewer migratory birds than other parts of the United States, although it is not poor in birds which come during the summer from the plains or from the coasts, and wander towards the mountains for breeding.

Every order of reptiles is well represented in the United States. Four adders, four rattlesnakes (*Crotalidæ*), and the very poisonous water snake, the moccasin (*Trigonocephalus controtrix*), are found, together with other not venomous species. The wheel lizards (*Ameivæ*), toad lizards (*Phrynosominæ*), and iguanas (*Iguanidæ*), are richly and characteristically developed. Crocodiles and alligators (*Kaiman* or *alligator Mississippiensis*) are also found. Among the turtles, the Old-World marsh turtles (*Emydæ*) are numerously represented, and the purely American group of the soft-shelled turtle (*Trionychidæ*) is not absent. The South American tortoises come into this region, and the snapping turtle of the east (*Chelydra serpentina*) is also found within it.

The eastern part alone far surpasses Europe in the number of forms of its amphibia. It is not without importance to our general idea of the animated nature of this region to know that the cry of the numerous kinds of frogs sounds different from the croaking uttered by those of our own continent. The smaller species give out a sound like the tinkling of bells or the concert of hundreds of chirping birds, and the largest kind, the bull frog (*Rana mugiens*), emits a low bellowing tone. Among the more remarkable forms are the tailed frog with the numerous varieties of salamanders. These snake-like, short-legged reptiles, some of them distinguished by gills hanging down from the sides of the head, include the *Siren lacertina amphiuma, Menobranchus*, mud devil or *Cryptobranchus horridus*, and eight other special kinds.

The prairie presents the spectacle of a curious social life existing between the most diverse kinds of animals. The prairie dogs are more numerously represented in the far west of America than any other animal, always excepting the locust. They are a species of rabbit, yellow or rather earth-coloured, but more lively than the common rabbit. How they obtained the name of "dog" is incomprehensible, for they have nothing in common with it, unless perhaps it may have been bestowed upon them because of their constant yelping and barking. They live in the earth in families of many hundreds, and often burrow for long distances underground, their subterranean dwellings being known as Prairie Dog Towns. There is nothing more amusing than to watch the proceedings of these charming little creatures. All the day long they may be seen outside their houses, going to and fro from one hole to another, sometimes sitting up on end like a squirrel, their fore-paws crossed over their breasts, sometimes gnawing at a root, but always alert and always in movement. The strangest thing, however, in the Bohemian existence of these creatures is that their home is shared by two curious lodgers, namely, night owls and rattlesnakes. And this is by no means the case only as an exception; on the contrary, these uncanny ingredients of Macbeth's famous incantation scene are invariably found in every one of the underground settlements. Sometimes, indeed, the trefoil is perfected into a true four-leaved clover, by the appearance of a fourth guest, the horned frog. It is most likely that the relationship existing between the prairie dogs and the rattlesnakes is too much like that of the mole and the hedgehog in the fable, except that the prairie dog does not allow itself to be driven out by its self-invited guest. It is only when the coil of rattlesnakes, which are found here in myriads, becomes too great, that the owls and the prairie dogs bid adieu to the halls of their fathers, and wander on arm in arm through this vale of tears, to begin life over again somewhere else. But sometimes the owl is as dangerous to the dogs as is the rattlesnake; for when too hardly pressed by hunger, its sharp beak treacherously splits open the skull of its bedfellow.

The number of fresh-water fish is very remarkable. Not a few waters have their own kinds; the Mississippi region possesses a peculiar fish of the sturgeon tribe, Columbia has a salmon, Lake Huron a perch (*Huro*), Gila, Columbia, and the rivers of Texas and California possess their own carp. Several families, including the bald and bony pike or alligator fishes (*Amiidæ* and *Lepidosteidæ*), are only seen in North America.

The number of valuable fish in the east and in the south is very great, much greater than in the region of the Pacific and the Rocky Mountains. Taking all together, the rivers and lakes of the eastern half of the United States probably contain no fewer fish of value than the fresh waters of northern or central Europe, and most of them belong to the same families. The sheat-fish varieties are very numerously represented, much more so than in Europe. Even though the different species are not so much esteemed as our own kinds as an article of food, yet their great abundance and the size of the separate fish make them a valuable addition to the dietary of the poorer classes. The far-famed cat fish is also valuable for the same reasons. Of perch, the little yellow perch and a larger kind about twenty-four inches long deserve special notice. The various species of bass (*Roccus* and *Labrax*) are some of the finest fish of North America. Pike is represented by our European kinds, and one or two other species. Of the salmon tribe, the mountain lakes contain several trout, but it is only in rivers flowing into the Pacific that the giant trout are found in immense numbers. Oregon, as is well known, supplies Europe with preserved salmon. White fish are represented by many of the *coregonus* tribe, which are found in greater abundance in the larger lakes, and are considered a great delicacy. Attempts have been made of late to acclimatise this fish among ourselves. Another numerous and valuable fish are the curious *Centrarchidæ*, or sun fish.

The sea fishery of the United States has been already mentioned in speaking of the abundance of fish found on the cod banks of Newfoundland. We have only to add that the little limestone banks which extend at a short distance from the coast across the whole space between Florida and North Carolina are simply called fishing banks on account of their superabundance of fish.

Among the molluscs the fresh-water kind are represented with that fulness which is a characteristic feature of the zoological physiognomy of North America. The fresh-water mussels (*Unionidæ*), of which more than 550 species exist, far exceed in number those belonging to all the rest of the world: 380 kinds of black snails (*Melania*), fifty-eight marsh snails (*Paludinæ*), forty-four round mussels (*Cycladidæ*), combine to form an unequalled fauna of snails and mussels. The abundance is so great that it cannot be considered, as in the case of the fresh-water fish, as an outflow of the great river and lake systems, but has to be accounted for in different ways, and from sources which have not as yet been described with sufficient accuracy by the historians of natural creation. North America possesses 240 kinds of land snails, eighty of which belong to the *Helix* or spiral snails, which are also most richly represented in our own continent. This is not a particular blessing; but, as is well known, the number of species of this group are closely connected with the construction of their dwelling-place; the more islands and mountains there are, that is, the more the land is broken up, the greater will be the number of varieties; the more unbroken the land, and the greater the facilities of dispersion, the greater is the uniformity of species.

The superabundance of fresh-water and sea molluscs is of no value to the white man, but affords plentiful nourishment to the Indians, and in some localities to the negroes. The former avail themselves chiefly of the great quantities of oysters found especially on the Atlantic coast; and, indeed, oysters prepared in a great variety of ways form an important article of food throughout the whole Union.

Of the 50,000 insects which are said to exist in the antarctic region, the beetles, estimated at about 12,000, are probably the most numerously represented. The stag-beetles are all European forms, and the same thing may be said of the majority of the different kinds of beetles. There are five genera of tiger beetles (*Cicindela*); goat-chafers are represented by 111 kinds, of which fifty-nine are peculiar to the region. Five hundred butterflies, classified as belonging to one hundred genera, are found, shewing that the nearctic region, once considered to be but poorly represented by these insects, is here as rich as the palæarctic. The likeness to European forms is very remarkable. If the comparison between the Old and New World were based upon the butterfly tribe alone, it would be difficult to distinguish between the nearctic and palæarctic regions. The other groups of insects are not accurately known with respect to their distribution throughout the region; but forty-five kinds of locusts (*Acridiæ*), with 237 varieties, have been already described, and in Texas alone there are 600 kinds of bees; but the attempts made to rear native honey and wax-producing bees of the Melipona and Trigona families have remained without success, and the ground seems to be reserved for our own honey bees.

Colorado Beetle (*Doryphora decemlineata*), with eggs and grub. (Natural size.)

The corn-weevil (*Curculio*) is so injurious to the flowers and fruits of the imported plum varieties, that in some places the cultivation of these trees has been entirely abandoned. A rather darker member of the family of the cockchafer becomes more numerous every year throughout the inhabited districts, and its grubs, which are exactly like those of the cockchafer, grow more and more dangerous to the potato and turnip fields. The Colorado beetle (*Doryphora decemlineata*) has been only too well known among ourselves during the last few years. A small yellow and black corn-weevil does great damage in the gourd, sugar, and melon plantations, by eating away the leaves. The burrowing grubs of the wood-beetle work much havoc among the conifers; but owing to the little attention paid to the forest timber, they are as yet almost unknown. The larvæ of the small grey night butterfly or moth, known as cut-worms, are highly injurious to the tender shoots of the maize and almost all garden plants. But the most dreaded of these enemies of plant life is the moth or cotton-worm (*Aletia argillacea*), which destroys almost yearly the value of several millions of pounds in the cotton plantations (in 1877, £3,000,000). Locusts are the terror of the prairies and North-eastern States; sometimes they appear, although in fewer numbers, in the Central and Western States. The most dangerous of the two winged insects is the Hessian fly (*Cecidomyia destructor*), brought over, as the legend has it, by the Hessians sold during the War of Independence; it is the deadliest enemy of the wheat harvest, depositing its maggots in the young shoots. Europe has received in exchange an equally undesirable gift, the vine-eating *Phylloxera vastatrix*, which has already destroyed millions of the vines of southern France. A kind of mite or bark-louse (*Aspidotus conchiformis*) is very dangerous to fruit trees. Mosquitoes, which, although not dangerous to man, are extremely unpleasant, are similar to our stinging-gnats; and the far more disagreeable black gnats are found in every place which has been freshly cleared, or is at all damp, and are much more numerous and importunate than their European kindred. The greater rainfall of the districts to the east of the Mississippi appears to be favourable for the multiplication of both dangerous and harmless insects, and the same may be said of the high summer temperature. Our own house pests, flies, bugs, fleas, etc., are found widely distributed. As a general rule, it may be said that the advance of civilization brings with it an increase of vermin, and, it is as well to add, an increase of insectivorous birds also.

As to other low animal organisms, the number of centipedes is estimated at 80 genera, spiders and crabs at 400 kinds respectively, brachiopoda 10, sea animalculæ 30, moss animalculæ 30, echinidæ 123, and of cœlenterata 144 kinds. Primeval forms are of course very insufficiently known. Imperfect as this list may be, it is yet sufficient to shew that out of the 264 marine echinodermata only 55 belong to the long stretch of the Pacific coast.

It is impossible to value too highly the contributions received by our own continent from Asia and Africa in the form of useful plants and domestic animals, whether brought over by Phœnician, Greek, or Roman, or exchanged between the continents in any other way. Who could imagine life in Europe without wine, coffee, tea, or sugar, without East Indian birds or spices, without the horse brought from the Asiatic steppes, the ass, or the cat? And yet it was only an early period in the intercommunication of continents which gave to us one and another of those precious commodities which we have now learned to look upon as indispensable. With the discovery made by the great Genoese began another epoch. We are still only on its threshold, and cannot as yet foresee how far the animal and plant life of America is likely to enrich or to dispossess our own. Even now almost every walk shews us some American importation. The so-called wild vine (Virginian creeper) (*Vitis Labrusca*) covers walls and colonnades, shewing us in the crimson of its autumn leaves something of the glory of the Canadian woods, but bestowing no generous juice like its eastern sister from the Caucasus: near to it rises the Peruvian *Tropæolum maius;* broad deep shadows are thrown by the American plane tree; hedges of North American robinias (called among us acacias) enclose our gardens, in which the American fir, the trumpet and tulip tree, greet us, together with large magnolia blossoms, delicate pepper trees (*Schinus molle*), and the magnificent coral tree (*Erythrina corallodendron*). In exchange for wheat, horses, and oxen, gifts of inestimable value, we have received potatoes, tobacco, maize, Indian fig (*Opuntia ficus Indica*), and turkeys.

Every one acknowledges what the potato is in the north; but comparatively few know that the Indian fig (*Opuntia*) is of the greatest value to the deserts and rocks of the Mediterranean region. Along all its coasts the prickly, blue-grey South American plant has covered the dry rock and stony ground, and by the formation of an earthy covering made cultivation possible. It is planted on the lava fields of Mount Etna, to accelerate the preparation of the soil for the reception of seed; its thorns protect the field, and its juicy fruit forms every autumn a great part of the nourishment and refreshment of the people. Among it, as its true companion, grows in full luxuriance the American aloe (*Agave Americana*), with its vast crown of leaves and its candelabra-like shafts of scarlet blossom; both together have altered so completely the character of Mediterranean scenery, that they are accepted by the painters of to-day as characteristic plants, and placed in the foreground of southern landscapes. The potato has never become a favourite vegetable in the south; but another member of the nightshade family, the tomato (*Solanum lycopersicum*), is so highly esteemed that its red juice colours almost every Italian dish, and is used whenever possible in all Spanish cookery.

On the other hand, the animal and plant life of America has also undergone great changes since the arrival of Europeans upon the continent; the Anglo-Saxon race, the creator of the Union, has won by laborious and incessant exertion in agriculture and cattle-rearing a new quarter of the globe, and one so important to our own continent that we must devote a little more time to its consideration.

The two great factors to be taken into account when determining the possibility of rendering any soil available for our use are climate and the construction of the ground. Generally speaking, it may be said that everywhere east of 100° west long. agriculture is possible, unless prevented by the presence of rocks and swamps; while to the west of this line it is only possible where the insufficiency of the atmospheric moisture is in some degree counterbalanced by artificial irrigation. On the one side, steppes and deserts prevail; on the other, wood and ploughed land. The western culture is also restricted by the rapid changes of temperature, sudden frosts, chill nights, and the early frosts of spring and autumn, which are so injurious to agriculture. It is true that these changes of temperature are also characteristic of the east, where they make the cultivation of the vine almost impossible, and restrict the growth of lemons and oranges to certain narrow limits in the south, but they are much alleviated by other counteracting influences, so that the fertility of the soil is only destroyed by an especially unfavourable construction of the ground. In climatic particulars the northern half of the east is very similarly affected to Europe, so that nearly all our objects of culture are found there, although many of them have undergone certain changes in adapting themselves to their new home. The climatic character of the south-east is quite unique; the warmth of the Mediterranean region being combined with a rainfall tropical in its violence and abundance, and allowing of a luxuriant tropical vegetation, and the cultivation of many semi-tropical plants known to commerce—as cotton, rice, and sugar-cane. The northern limit of this culture may be approximately determined by a line drawn 34° N. lat., and for the western limit at 100° W. long. To the north of the cotton zone lies the corn district, and that of other plants found in the corn-growing countries of central and northern Europe. This section of the country may be divided into a northern and southern zone; but the latter is of relatively small extent; in the former maize, and in the latter wheat is the chief object of culture.

The district where corn is grown most successfully and in the greatest abundance is where the central course of the Mississippi comes nearest to the great lakes—Illinois, Ohio, Indiana, Minnesota, Wisconsin, Iowa, Missouri, and parts of Kansas and Nebraska. This territory of more than 360,000 square miles is the granary and storehouse of North America, and sends out year by year immense quantities of its produce to foreign countries. Every requisite for successful agriculture is here found united; fertile soil, more than sufficient heat from the sun, moderate but evenly distributed rainfall, and tolerably settled weather. Drought, that dreaded enemy of Hungary and southern Russia, which enjoy a rainfall of only two-thirds the amount of this portion of America (from thirty-nine to forty-three inches), is scarcely ever experienced here.

Rightly, therefore, is this rich, black, loamy soil designated "the fertile

SWAMP IN FLORIDA, FREQUENTED BY FLAMINGOES AND PELICANS.

belt;" especially when it is compared with the east. For, in the first place, the whole north-eastern angle between the Hudson, the St. Lawrence, and the sea, a territory including the six New England States, and a part of New York State, possesses a cold climate and a poor stony soil, by no means favourable to agriculture, so that during the last few decades the number of its agriculturists has greatly decreased, and many of them have emigrated to the far West. Even in New Hampshire many farms have been abandoned, and are gradually relapsing into the condition of wood and heath; and in Massachusetts and Connecticut, within the last twenty years, several farms are now covered with fir trees, or have become overgrown with bush and scrub. Farther southward, where the Alleghanies retreat to a greater distance from the coast, they leave between themselves and the coast a spacious well-watered valley, which is very fertile, especially to the south of Virginia. It is true that many a hundred thousand acres are still lying fallow after having been exhausted by a reckless culture of ten years' uninterrupted sowings; but it is said that these waste places are soon covered again by fir trees. The only really unfruitful places are the swamps along the coast, of which the Dismal Swamp of Virginia and North Carolina occupies 300 square miles; while in Florida half the ground is unfit, from its marshy nature, for any kind of culture. The pine barrens are not particularly fertile; but the Alleghanies are on the whole more favourable to agriculture than most of the central mountain districts of Germany, and often possess the most favourable conditions for cattle-rearing.

Widely different is the steppe region, which, as far as regards the absence of agriculture, comprises many a tract of land to the west of lat. 95°. According to impartial estimates, we find even in the best situated states only a fifteenth or twentieth part of the soil repaying cultivation, and in the less favourably placed not more than a hundredth part; so that the boastful song of Uncle Sam, that he was "rich enough to give every one a farm," sounds strangely in the steppes of the west. How far the wide steppes of the west, unfit for agriculture, may be utilized for cattle-rearing, is a problem which awaits its solution in the future, as the attempts in that direction are yet in their infancy.

In California, the north, by its wild, mountainous character, and the south, by its dry climate, present obstacles to the development of agriculture, which is restricted to narrow limits, and perhaps only half the area of the State, which however, it must be remembered, is a very large one, can be termed without any qualification capable of culture; and, even then, the soil almost everywhere needs the aid of irrigation. To this small percentage of soil suited for agriculture we must also add the climatic peculiarities, with all the uncertainties of harvest which they entail. Both in its agriculture and its cattle-rearing, California has experienced some years of unmitigated failure, such as are never known in the east; for both there and in Texas there have been years of drought, which have not only damaged the harvests, but have also diminished the stock in the cattle stations by a third or a fourth part.

The following table of comparison between the objects of culture in the Old World and in the New has been drawn up by Peschel:—

OLD WORLD.	NEW WORLD.
Corn and Pulse.	
Wheat, rye, barley, oats, millet, buckwheat, rice, lentils, peas, vetch, beans, igname.	Maize, mandioc, potato, batata, igname.
Fruits of the Temperate Zone.	
Vine, apple, pear, plums, cherry, apricot, peach, fig, orange, date.	Catamba, grape.
Fibrous Plants.	
Cotton, flax, hemp, mulberry (for silk-worms).	
Spices.	
Pepper, ginger, cinnamon, nutmeg, cloves, sugar-cane.	Vanilla, Spanish pepper.
Narcotics and Stimulants.	
Tea, coffee, opium, hashisch.	Paraguay tea, cocoa, tobacco, cacao.

But it is easy to shew that the above list does not do justice to the produce of America. Numerous leaves and roots are edible; other plants are used for salads and vegetables; water rice and a lupine yield their grain for food. The fruit of the wild citron or mandrake (*Podophyllum callicarpum*) is refreshing, and that of the *Diospyrus Virginia* is considered excellent. The plum (*Chrysobalanus icaco*) resembles our Damascus plum. The melon tree, or wild papaya (*Carica papaya*), bears a fruit like the melon, which is eaten as a preserve. Wild plums and cherries of several kinds are found in many places. The fruit of the wild apple tree is not eatable, but the *Pyrus coronaria* bears a pleasant-flavoured crab apple. Two kinds of chestnut, *Castanea Americana* in the Central, and *C. pumila* in the Southern States, bear edible fruits. The north has its two varieties of hazel nuts (*Corylus*), and the south its witch hazel. Sweet acorns are procured from the chestnut oak (*Quercus castanea*), which is found as far north as 43° lat., from *Quercus alba*, and live oak. The nuts of the *Juglans nigra*, *cinerea* (butternut), and *Fraxinifolia*, of *Carya olivæformis* (pekan nut), together with other kinds of hickory nuts, replace our walnut, but have thicker shells and smaller kernels. An edible nut is also procured from *Hamiltonia oleifera*. The palmetto (*Chamærops palmetto*) contains the so-called palm cabbage in the buds of its leaves. The leaves of the American agave are said to make an agreeable dish when cooked. In the south-west, the leaves of a few cactus varieties, particularly the opuntia (*Tunas*), and the giant cactus (*Saguarro cereus giganteus*) are eaten. In the same place, the oily, resinous kernels in the cones of certain firs (*Pinus edulis monophylla*) play an important part in the food of the Indian races. Among the edible mushrooms, of which there are a large number, the so-called Indian bread (tuckahoe, *Lycoperdon solidum*), a fungus weighing sometimes as much as thirty pounds, and found in the Southern States, deserves special mention. Most of the edible berries found in Central Europe, raspberries, blackberries, currants, and gooseberries, are also found in North America, and are frequently represented by several varieties; but unfortunately the most valuable plants are often restricted to places where it is very difficult for men to reside; thus the water rice and cranberries grow in the swamps, and huckleberries upon the barren heights of the north-west. Nor must the wild vines be forgotten, several varieties growing freely in the United States. Even in the steppes of the Upper Red River Territory numerous wild vines are found half buried in the driftsand, but perhaps all the more fruitful for their warm covering. In some places they extend over hundreds of acres, which look like vineyards. It is said that they are so loaded with fruit, that every part of the stem is covered, and the grapes are "incomparably finer than those of any other native or foreign vine." (Lang.)

Another plant which is of importance to the house-keeping of the inhabitants in the north is the sugar maple (*Acer saccharinum*), which yields a substance known as maple sugar. The juice obtained from the sugar pine (*Pinus lamberliana*) resembles manna in appearance, and is readily taken by the white population of the Sierra. Panoche is the name given to a sugar produced by an insect on the leaves of the sedge, and eaten by the Californian Indians.

Peschel compares also the Old with the New World in the following list of domestic animals, in which he includes those which have actually been tamed, or those which may be considered to have been capable of domestication :—

Old World.	New World.
Reindeer, ox tribe, camel, dromedary, pig, elephant, dog, sheep, goat, horse, ass, fowls, ducks, geese.	Reindeer, lama, vicuna, porcupine, water-pig, tapir, dog, turkey, hokko fowl, musk duck.

But this list cannot be accepted as complete, although, in the absence of wild horses, camels, oxen, goats, and elephants, no one will doubt that, as far as the possession of useful animals is concerned, America is far behind the Old World. Many attempts have been made to introduce several breeds, but with the exception of the dog and turkey in North America, they have not been attended with much success. The attempts made to domesticate the buffalo are interesting, and seem to promise a probable success.

It would be difficult to understand the development of the United States, if we were to forget that, with the exception of the west, where the Spaniards in Texas, New Mexico, and California, have introduced rancho cattle-farming framed on the Mexican model, and a few of the younger States, the first settlers of which were miners, every part of the United States was originally an agricultural colony. We know from Bancroft's history that one of the reasons which obliged the Puritans to exchange the asylum offered to them in the Netherlands for the rough soil of New England was the impossibility of devoting themselves to agriculture in their European refuge. On their arrival in New England they at once parcelled out the land entirely with a view to agriculture, which was intended to be the principal means of livelihood for all, without any exception; and in the list of articles sent out to them from the mother-country the first place is occupied for many years by different kinds of seeds, roots, seedlings, poultry, and cattle. Before long the land and cattle-rearing returned more than they needed, and Virginia, which had become the home of adventurers eager for gold and silver, devoted itself to the tobacco culture, notwithstanding the many efforts made both in England and America to substitute other objects of culture, especially vine-growing and silkworm rearing. A different future was reserved for cotton, rice, and sugar-cane. Attempts to introduce these plants into Virginia were made soon after 1621, but with such indifferent success that in 1748 only seven bales of cotton appear among the exports from Charlestown. It was not until the invention of the saw-gin machines, toward the close of the past century, by which the cotton was more speedily purified from the seeds, that the trade attained a rapid development. Sugar-cane was brought over from San Domingo to Louisiana in 1751, and has been cultivated there ever since, not, however, becoming an important article of trade until about 1790; the Java cane, which is now almost exclusively cultivated in the United States, was first introduced in 1814. Negro slavery was of great importance in the carrying on of this sub-tropical cultivation, enabling vast stretches of territory to be worked at a small outlay of money. Slave labour being so inadequate, the plantations did not repay expenses, except on very fertile soil. The American agriculture of the Southern States is chiefly indebted for its extremely rapid development as far as the Mexican frontiers, and throughout the entire basin of the Mississippi, to the constant search after fresh, wide-spreading, thinly populated tracts of land, which was a necessity of the employment of slave labour. It is an idle question now to ask whether the Southern States could have reached the same height of agricultural development without the aid of slave labour. In 1860, the year before the outbreak of the War of Secession, the amount of such produce was estimated as follows: Cotton, 11,000,000 cwt.; sugar, 466,600 cwt.; molasses, 12,500,000 gals.; tobacco, 7,900,000 cwt.; and rice, 3,350,000 cwt. It is indisputable that the emancipation of the slaves inflicted a blow upon all these objects of culture, from which they only recovered by very slow degrees, with the aid of a great expenditure of capital, large reinforcements of emigrant labour, and a much more energetic management on the part of the owners. It is true that the amount of work done by the free negroes is much greater than was anticipated, but the cultivation of the Southern States has at present only exceeded in the one article of cotton the amount exported in the year 1861.

In the Free States agriculture and cattle-rearing depended upon the energy of the individual settler for their development; the colonist having, as a rule, to make the very first beginnings of culture for himself. He had the choice of two methods, which are practised at the present day—(1) A regular clearing, by which every tree is cut down in succession, row after row, the trunks and branches being at once cut up and stacked; and (2) the so-called belt system, by which, in June or July, the larger trees are cut round, so that they dry up, and the ground beneath them can be cultivated. In this case the trunks are left standing until blown down by the wind, and the stumps remain in the ground till they are sufficiently decayed to be removed without much trouble, which generally happens in five years for the smaller, and ten or more for the larger trees. It is easy to understand the difficulties which such rough land presents to the plough; and, in order to decrease this, the fields, after being ploughed once or twice, are turned into grass land, until a number of the roots and knots have decayed. Either potato or maize is chosen for the first crop, both of which thrive well in the virgin soil, as yet clear from weeds. Of course the work of preparing the ground is altogether different in the prairies and the transition districts. In the latter districts the farmer has only to clear away the shrub and smaller trees; the larger ones, so far from being injurious, are useful in these relatively treeless neighbourhoods. Prairie firing, formerly much used to clear the land from tree-stumps, snakes, and insects, is now seldom practised, as the fire destroyed all but the coarsest kinds of grass, and so was the direct cause that these inferior grasses were the only ones produced by the soil. The inherent fertility of the new soil is naturally relied upon by the settler as long as it exists, and equally naturally the demands made upon it are often repeated until it is absolutely exhausted. We may assume that the poorer soils can bear good harvests for five years without the aid of manure, the better kinds ten, and the best black valley soil for twenty. But, as a rule, the manure is withheld for a much longer time, and

COTTON PLANT (*Gossypium herbaceum*).

the ground left in a most exhausted condition. The consequence is that in all the States where the ground has been long under culture the crops are less heavy by one-half, sometimes indeed by one-fourth, than those obtained from the new land in the Western States. Year by year fertility wanders away to the westward, both from north and south; for example, in 1849 only about 12½ per cent. of the cotton came from beyond the Mississippi, while in 1869 the same district produced 30 per cent., and in 1876 the yield had risen to 37½ per cent. These results are partly due to the development of agriculture in the West; but partly also to the exhaustion of the soil in the Eastern States. An official report estimates the exhausted and fallow land of the Southern States at more than 126,000 square miles; and it is said that one-fourth of the land of Virginia once cultivated is now left to itself, and covered with bush. The rotation of crops, which is so important in the preservation of a healthy state of the soil, is generally regarded as unnecessary, for a constant succession of the same sowing over an extended tract of land is found to be the best way to make a fortune in the shortest time, and with the least trouble. It is only in the more densely populated Eastern States, which have been long under culture, that the rotation of crops has of necessity become the rule. The most usual succession is that of wheat or maize and clover.

America owes so much to the acclimatisation of plants and animals from the Old World, that it is easily understood how, in spite of many failures, the firm conviction of the possibility of acclimatizing almost all the useful plants and animals of the Old World is still part of the creed of every North American farmer. The only attempts of this kind, however, which call for notice at present, are those made with respect to the introduction of tea from China, and of the camel. Of the former it is confidently expected that it will become "one of the staple articles of our field produce;" and camels, which have been introduced into Nevada and a few of the desert states of the West, are already in use, and multiplying rapidly.

The most important object of agriculture is maize, or Indian corn (*Zea mayo*). According to the official report, the harvest of the year 1877 amounted to 162,250,000 quarters, while the total amount of all other kinds of grain, wheat, barley, rye, oats, buckwheat, and all leguminous plants, did not nearly equal the above result. Now as the quantity of maize exported is but a very small proportion of the amount obtained—for example, in the year 1876-77, one-nineteenth, and in 1877-78, one-eleventh of the harvest—we gain some idea of the large consumption in America, where we must remember that not only the grain, but the straw and stalks of the plant are made available for farming operations. Great as the distribution of maize has been in the Old World since the discovery of America, it has nowhere been so extensively cultivated as in its American home. Especially in the United States, where the culture resembles in many respects that of our own continent, the great preponderance of this special object of culture necessitates many essential differences which influence more decidedly than we are generally disposed to believe the whole agricultural life of the nation. Maize is found distributed from the Gulf to the frontiers of Canada, and from the Atlantic to the Pacific, for its unusual powers of adaptability render it suitable for the most opposite outward circumstances. Moreover, it is a favourable circumstance for its growth, that all those qualities which are chiefly taken into account in the culture of any cereal are capable of variation in maize—such as the time of ripening, height of the stem, abundance of leaf, size of the ear, number of grains, size, shape, hardness, and mixture of the seeds. At the present time the home of maize culture is, and most likely will continue to be for a number of years, the vast region between the Mississippi, Ohio, and the coast.

Next to maize, wheat is the most important cereal, and is grown less for home consumption than for exportation, about 13,000,000 quarters having been exported in the year 1877-8. The principal markets are England, Canada, Brazil, and France; but in Germany also the current price of corn is affected by the American wheat. The corn-growing lands are found in the same district which produces maize, but they extend farther westward to the shores of the Missouri.

Rye is very little grown, and has no market whatever in America itself, being cultivated only by a few Scandinavians and North Germans, who are accustomed to rye bread.

Since the introduction of the different kinds of German beer, the culture of barley has increased, and is now equal to that of rye.

Oats, which rank next to wheat in importance, are generally sown in the poorest soil. In the West it is usually preferred for the first crop on new land, and realises a good price in districts where there is a lack of hay during the beginning of the forest clearing.

Buckwheat is sown in all the States; chiefly as a second crop. The climate is favourable for peas and beans, and yet the culture of the latter vegetable has decreased greatly within the last ten years, because the blacks, who before their emancipation were fed from year's end to year's end upon pork and beans, prefer now to live, like their masters, on wheat and maize.

Irish potatoes rank, as in central and northern Europe, among the most important objects of culture. Their southern representative is the sweet potato (*Convolvulus batatas*), which is still grown in Ohio States as a garden vegetable.

Turnips, etc., are grown nowhere but in the north, and then only for fodder. Besides our ordinary salad herbs, most of which are less frequently used in American than in European cookery, the favourite vegetables are tomato and its kindred plant, *Solanum melanogena*, or egg-plant, squash or pumpkin, melon, especially water melon, and rhubarb, none of which are absent from the garden of any farmhouse. Tomatoes are eaten in quantities, and rhubarb tart and pumpkin pie are so decidedly *de rigueur* at every festive gathering, that they may be looked upon as national dishes.

Among fibrous plants, "cotton is king," and beneath its sway flax, hemp, and agave are gradually decreasing in importance.

The cultivation of the sugar-cane is not unimportant; but, according to the report of the Commissioner of Agriculture for 1877, it is gradually diminishing, owing to the general overturning of all agricultural operations, which resulted from the abolition of slavery: the want of skilled workmen and of sufficient capital is severely felt. Even according to the most optimist view, such as generally finds its way into an official report, it could not be denied that the supply of sugar would be inadequate to meet the constant and ever-increasing demand, even though it were supported and encouraged by extensive government aid.

Guinea corn (*Sorghum vulgare*), has within the last thirty years been cultivated in the Central States of Ohio and Mississippi, both as a cereal and for fodder, and also as a kind of substitute for the sugar-cane, as many people refused to sweeten their tea with sugar obtained from the slave plantations, lest they should be paying out of their own pockets to enrich the slave owners.

Tobacco, now, as 250 years ago, when its cultivation had to be restricted in Virginia because of its exclusiveness, is considered to be the most remunerative of agricultural products, but its cultivation under present circumstances has become a very different and perhaps a more sensible matter than it was some sixty or seventy years since. The small farms are better suited to its cultivation than the large slave plantations used to be, because only the finest brands of tobacco, such as could seldom be procured on the plantations, command a good market in the present day. Tobacco is most largely grown in Kentucky, and next in Virginia, Tennessee, and Missouri.

Hops are grown chiefly in New York.

Indigo, once one of the staple articles of plantation culture, is now scarcely grown anywhere, although the plant is still found wild in Georgia and South Carolina. The exports, which in the year 1794 amounted to 1,500,000 lbs., had diminished in 1850 to about 3,000 lbs., and in 1876 nearly 1,000,000 lbs. was imported.

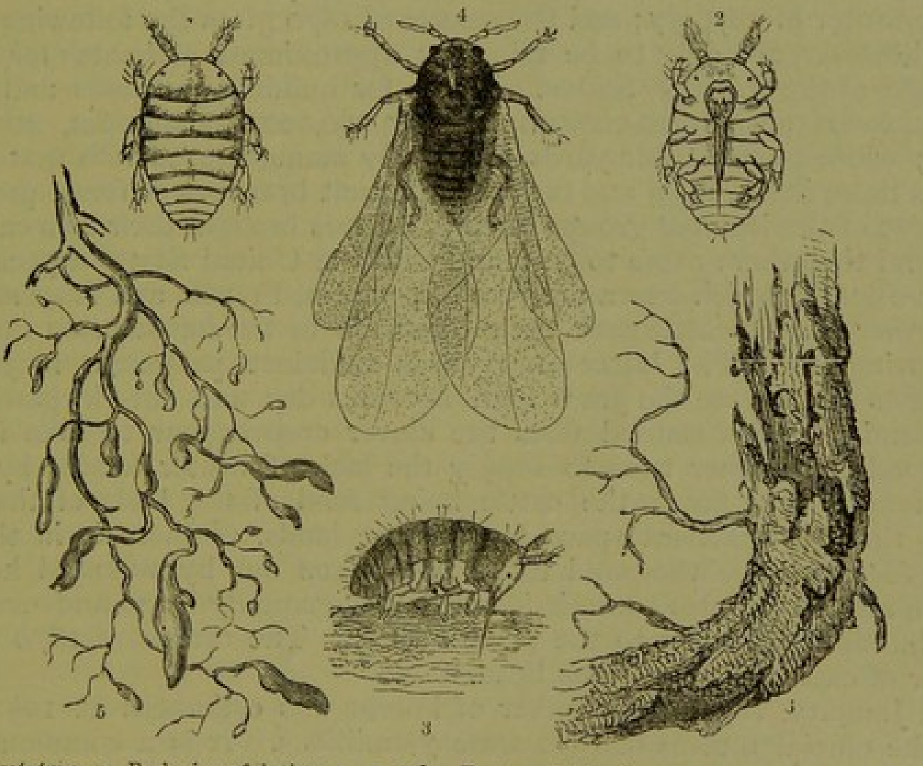
Rice, once confined to the marshy coast lands of the Southern States, has now made its way into the lowlands of the Mississippi States, where it is considered to be more profitable than sugar.

According to a table drawn up in the year 1878, about 4,500,000 acres were devoted to the culture of fruit trees; 112,000,000 apple trees, 28,000,000 pear trees, 113,000,000 peach trees, and 142,000,000 vines, were entered. The value of an average fruit harvest was estimated at £280,900,000, or about half the value of a good wheat harvest, and as much greater importance is attached to the exclusive growth of good sorts, than is unfortunately the case among ourselves, the American fruit is threatening to drive all others out of the English markets. The climate seems to be unfavourable to the growth of cherries and apricots, but plums are largely cultivated.

We have still to mention among the special fruit trees of the Southern States the orange and mulberry trees; the latter are also found in the Central States. Lemons and almonds are of less importance as articles of commerce.

North America possesses several kinds of native grapes, some of which bear abundant and excellent grapes; but the vine was not seriously cultivated in the eastern parts of North America until about the year 1690, when the colony of Virginia sent over to Europe for vines and vinedressers from France and Germany. But notwithstanding great encouragement on the part of the local and central government, the culture has only partially succeeded in isolated cases; perhaps because the phylloxera devastates the vintage. Indeed, the attempts were always of rather an amateur character until the present century, when in the Ohio valley the Swiss and German emigrants busied themselves with the vine plantations, and even now the culture is only carried on on a large scale in certain portions of a few states, particularly Missouri, Ohio, and Illinois. On the other hand, the incorporation of California into the United States has given to the Union a large tract of vine-growing country. The greatest production of wine, as shewn by the census of 1870, was found in the following States: California, 1,507,000 gallons; Missouri, 264,000; Ohio, 187,000; Illinois, 88,000. As to the grapes, they are, as a rule, native kinds in the east, the Southern States cultivating the muscadine grape, which is found growing wild there (*Scuppernong*, or *vitis rotundifolia*), and in Ohio and Missouri the Catawba and Isabella grapes, varieties of the fox-grape (*Vitis Labrusca*) European kinds, in spite of all the efforts and care bestowed upon their culture, have not succeeded for any length of time; while in California, although it possesses native kinds of its own, cultivates none but those which are either altogether or partially of European origin. The mission grape, so called because it was first cultivated in the Spanish Indian Mission, is a descendant of Spanish vines. Besides this, several varieties of German, Hungarian, and French vines are planted, and yield satisfactory results, although the German kinds seem to have a tendency to produce more saccharine matter, and to develop in their wine greater body at the expense of the aroma.

We must not forget to speak of the forest land, which is estimated at 25 per cent. of the whole area. The United States therefore have more forest land than any European country, excepting Scandinavia (63 per cent.), Russia (31 per cent.), and Germany (26$\frac{3}{5}$). Little care has as yet been bestowed upon the preservation of forests, and a reckless system of destruction has generally been the only method applied to them, whether the object was to procure



Phylloxera vastatrix. 1. Back view of the insect. 2. and 3. Front and side view, the latter sucking. 4. Winged insect. 5. Section of root, with swellings caused by insect. 6. Older root, with hibernating insects. All strongly magnified.

timber or land. In one place immense tracts of land, in another millions of square yards of timber, were ruthlessly devastated and destroyed. Only in the Western States where Nature had been less lavish in her gifts of this kind, was any attention bestowed upon the planting of new forests. It was not until the year 1875 that the government of the Union followed suit with a law which gave to every man who should plant a certain portion of the ground in the manner prescribed by the regulation, a grant of government land. There is not much to be said at present as to the result of this law, but the reports from the steppe states shew that the plantation of trees, especially of conifers, from other parts of America, is anything but a success. And of late years the central government has turned its attention also to the preservation and protection of woods and forests, partly in the interest of national property, and partly for the general good of coming generations. It is rightly pointed out that the allotment of coniferous (especially fir) plantations under the Homestead Act was an "act of mistaken benevolence, which must cause great mischief in the future," for such land is almost always unfit for agriculture and permanent settlements, and therefore nullifies the very object which the Homestead Act intended to effect. Thus not a trace of agriculture is to be seen upon thousands of acres of fir woods near the Lake Superior, round the Upper Mississippi, in the Pacific States, or the Rocky Mountain territory, now in the possession of private individuals under the Homestead Act. The Act was made use of, on the contrary, to obtain greater facilities for gaining money by the destruction of these woods, and there is certainly a want of consistency in bestowing a tract of land in the comparatively treeless states on the man who plants it with certain trees, and at the same time lavishing the best forests upon so-called settlers, who are in reality nothing but speculators. The felling of timber is enormous. Thus in the pine woods of the north of Minnesota more than 40,000,000 yards were cut down during the one winter of 1876-77; and the census of 1870 gives the following returns which, however, are only to be taken as approximate estimates for the timber trade of the United States. Wood for building purposes and for fuel 1,275,000,000 tons, 1,300,000,000 laths, 3,250,000,000 shingles, 400,000,000 beams; while 10,000 cubic yards are yearly manufactured into matches, etc. Besides these items, resin and tar are important branches of forest production.

Most of the isolated groups of early settlers brought their own cattle with them, and thus there came to be found with the United States a peculiar race of native stock, which was a mixture of Spanish, French, and English breeds. The farmer lets his cattle seek their own food in the forest or on the prairie after springtime. The latter only yields sufficient pasturage in June and July, after which time the grass soon becomes dry, and only in places where high farming is understood does the clover crop appear to take its place. The woodland farmer tries to supply the lack of winter fodder by cutting down maples and limes, the cattle being fond of the buds of these trees. Where there is sufficient space for pasture lands, as there is in the West, herds of four or five thousand cattle are driven out by mounted herdsmen, who are also sometimes commissioned to drive equally large and even larger herds hundreds of miles to the place of sale. The census of 1870 gave the number of cattle as $23\frac{4}{5}$ million head.

In January, 1878, the number of horses was estimated at $10\frac{1}{3}$ millions, while the official returns of 1870 were $7\frac{3}{4}$ millions. It is a common boast in North America, that that country possesses one-eighth of all the horses in the world. But together with this great number there exists also a mixture of breed, which is regarded with less satisfaction. The horse of Spanish descent, which has passed through the transition stage of the wild prairie horse, is the ground stock of the race.

Sheep rearing has only existed on a large scale within the last two centuries. The primitive settlers found the pig more useful than any other kind of animal, except, perhaps, the dog, and pig breeding has consequently attained great importance. Pigs are allowed to roam freely in the uncleared forests, where they find such abundance of food that under favourable circumstances they go through a regular process of fattening till toward the end of autumn. Where this is not possible, they are turned into the maize fields, which are made over to them in divisions. In 1878, the number of pigs was more than $32\frac{1}{4}$ millions, and in 1877-78, the "pig-harvest" amounted to $12\frac{1}{3}$ millions, of which number four millions were killed in Chicago alone, which has gained the name Porkopolis, and in 1876-77, the value of all the articles obtained from these animals was £16,350,000.

We must not forget the dogs, which are of special importance to the inhabitants of a country containing so many scattered and solitary farms and homesteads. In 1866, a report estimated their numbers at 5,000,000, and added that during the same year 130,000 sheep had been killed and 300,000 mutilated by them.

In the poultry yards the turkey naturally claims precedence. Silkworm rearing and beekeeping are unimportant.

THE SOUTHERN PRAIRIES AND THE MEXICAN TERRITORY.

The climate of the southern prairies resembles that of the northern, but with less marked variations of season; the period of vegetation, however, does not gain in duration by this comparative uniformity. It extends here from spring right into the summer; but although the winter fall of snow ceases earlier, the dry season and the parched state of the ground lasts longer. The sea winds exert an influence upon the sloping ground which descends toward the gulfs of Mexico and California, so that the climate is moister in that district than in the interior.

The Mexican territory is divided into climatic regions, which have even received distinctive names in the language of the people: the coast lands, up to four thousand feet above the sea level, are called the hot lands, or *Tierras calentes*, and their temperature varies between 59° and 100° Fahr. Above them, to the height of 5,850 feet, rises the temperate zone, or *Tierras templadas*, with an average temperature of 68°; and highest of all, the cold region, *Tierras frias*, with an average temperature of 57°, which is nearly that of Naples; but no comparison can be made between the climate of Italy and the Mexican table-land, since in the latter country there is only a difference of 11 degrees between the summer and winter temperature.

Both the fluctuations of heat and cold, and the distribution of moisture, favour the richest development of vegetable life. On the eastern side of the Mexican plateau, the trade-winds bring the water-laden vapours of the Gulf, and the moisture is so abundant that every vegetable product of the tropics is able to grow to full development, and even in the vicinity of the tropic of Cancer we seem to recognize the equatorial scenery of South America. On the Pacific side of the continent, from the tropic to the isthmus, the duration of the rainfall is shorter, but on both sides the rainy season follows the course of the sun. The coasts and the shallow slopes are not able, of course, to condense the aqueous vapours of the trades, and they are consequently excluded from the blessings of the showers of rain, and thus it happens that lower Yucatan presents such a striking contrast to the adjoining state of Tabasco, and appears entirely destitute of forest land—a flat, stony, hot, and parched savannah. On the coast alone do we find the extensive campeachy woods to which Yucatan is indebted for its importance; but the best blue wood (*Hæmatoxylon campechianum*) is now obtained from Tabasco. The vegetation of the cold zone is affected in a far higher degree by the drought of the plateau climate than by the temperature. In this place the winds blowing from the Gulf have lost their moisture, and the rainy season, which often lasts nine months in the temperate zone, is limited to the space between June and September, and is not even sufficient everywhere to guarantee the fertility of the soil. The plateau resembles the southern prairies, both in the character of the vegetation and in the period of the rainy season, and the distinction between the two districts consists merely in the greater uniformity of temperature.

The tree growth of the northern and of the southern prairies is restricted to the mountains and the river valleys; they possess also a considerable number of corresponding species and of saltworts. We find in the district now under our notice many remarkable forms, such as the forests of post oaks (*Quercus virens et stellata*), along the lower course of the Rio Grande, and the plantations of piñons, a fir (*Pinus edulis*) with eatable fruit, while large tracts of land are covered with horse-tail, a shrub about three feet high, and resembling the European broom, although belonging to the coniferous ephedra (*Ephedra Americana*). The approach of the flora of the southern prairies to that of the Mexican cold region is indicated by the greater variety of the succulent plants, cactus and agave, and by the widely distributed mimosas, especially the *Mezquite* or *algarobilla glandulosa*, and thorny shrubs.

The dry climates of America are sundered from those of all other parts of the world most sharply by the possession of the cactus tribe. This group of plants was originally found nowhere but in America, and forms a large independent family, containing, as far as is at present known, more than one thousand species. It developes its highest forms of growth, such as we are accustomed to see in our conservatories, upon the rocky savannahs of Mexico and the South American Andes. In the neighbourhood of Colorado they are subject, during the winter, to a diminution of their juices, and assume a reddish hue, such as we may see for ourselves in many of our own plants, especially in conifers and beech trees, as if the long, uninterrupted period of growth were a necessity for them, which they cannot perfectly satisfy here. But notwithstanding this interruption of their life energy, which may be called their winter sleep, the southern prairies exhibit as large a variety of special kinds as are to be found in the tropics, almost all the principal forms of the order being found represented. But beyond this point they begin to decrease in number as we advance northward, until at Rainy Lake, beyond the Missouri, only one opuntia (*O. Missouriensis*) is found remaining.

In the southern prairies of the west, especially in the river basin of the Gila, the cactus form attains its highest development of growth in the pillar cactus (*Cereus*), and the monument cactus (*C. giganteus*). They rise alone in the midst of the desert, needing at first the aid of some protecting shrub, but soon standing erect and unsupported, like thick cylindrical columns, forty-five to fifty feet high, and sometimes twenty-four inches in diameter, and, as exhibiting one of the most grotesque plant forms of the world, suffice to impress upon the south-western prairie its characteristic appearance. They rise at long intervals from the bare soil of the rocky river valleys, and would resemble the columns of some ancient temple, were it not that they frequently send out a number of arching, strong, upward-growing branches, single, thick, and irregular. They can scarcely be called the ornament of these barren solitudes, but they arouse our wonder at their massive architecture and the hidden forces of development, which are able to store up such a wealth of sap and organic matter from such meagre sources. A fig cactus (*Opuntia arborescens*) generally only six feet high in East Arkansas, is said to grow in Mexico to the height of eighteen to twenty-seven feet; it forms, like the other flat-leaved, usually flaccid fig cactus, a singularly wide plant-body by its branching growth. A plant belonging to the melon-shaped hedgehog cactus (*Echinocactus Wislizeni*) is found in New Mexico, of shapeless growth, sometimes resembling a barrel, and growing to the height of fifty-two inches, with a diameter of twenty-six inches. Its flowers, a glaring red or white, break forth from the green stem in unexpected places, and are often of considerable size, and, like the Indian figs of Sicily, the succulent fruit of the monument cactus and other Indian varieties, is regarded as a source of abundant nourishment among the scantily distributed gifts of the prairie.

All these forms are found in Mexico, together with numerous other kinds which it would take too long to enumerate. The principal varieties are the Mammillaria, Rhipsalis, Melocactus, Epiphyllum, and Phyllocactus.

Another remarkable succulent plant is the agave, which is not found beyond 35° N. lat. Its large succulent crown of leaves grows in the dryest soil, and needs many years before it blossoms. After blossoming, it withers soon after the fruit has ripened; but as by its runners it continually renews its youth, the constant growth of the original plant creates at the time of the rainy season, in an annually recurrent revolution, fresh tall flower stems, whose sugary juices flow for months together from the wound made, and, together with the pith of the lopped stem, furnish food and drink. Our so-called hundred years aloe, the maguey (*Agave Mexicani*), is the best known variety. Scarcely less useful is the giant agave (*Fourcroya gigantea*), a fibrous Mexican plant also cultivated in Brazil. Mexico is also the home of the beautiful flowering *Echeveriæ*, and of many bromelias, among which the *Ananassa sativa* is not the least important, and many liliaceous trees (*Dasylirion* and *Yucca*). In the north of Mexico, the yucca, or bayonet tree, which begins near the Missouri with a dwarf, stemless form, grows to the height of thirty feet, and often rivals the palms, among which it is seen, both in height and in the size of its leafy crown. The most common kinds of palms are here the *Chamædoreæ*, the smallest being found in the moist mountain forests, and the taller stems on the coasts. Special kinds of cycads (*Dion*, *Ceratozamia*) equal the palms in height and growth.

A general survey of the distribution of plants in the different heights of Mexico is best afforded by an excursion to the volcanic mountain of Orizaba, near to Vera Cruz. This peak, which is 16,380 feet above the sea level, presents an uninterrupted view of the vegetable regions, such as is obtained from no other mountain height. The sandy coast washed by the sea is burning hot, and bare of all plant life. The dunes are covered with coarse shrubs and climbing plants. At 180 feet above the sea level we find a grassy plain, nearly four miles and a half in width, immediately beyond which is a dense wood of mimosas, acacias, tall palms, lemon, and cotton trees (*Bombax*). As we ascend slowly we see opening out before us a savannah of not very luxuriant grasses (*Paspalum*). Low mallow shrubs (*Sida*), and mimosas, among them the sensitive plant (*Mimosa pudica*), yellow flowering bignonias, and tree convolvuli, with white funnel-shaped blossoms (*Convolvulus arboreus*), offer but little variety along the path of thirty miles in length. Forests of evergreen oaks, containing more than twenty varieties, cover the succeeding zone between 2,400 and 4,800 feet, but the tropical representatives of the laurel form—laurels, anonas, sapotaceæ, myrtles, and others—are found everywhere, and the undergrowth is composed of little palms (*Chamædoreæ*), cone-bearing palms, tree fern, wooded compositæ, and melastomaceæ, towards whose home we are drawing nearer. There is no lack of magnolias, yuccas, horse-chestnuts, planes, and the amber gum tree (*Liquidambar styraciflua*), but the crowning beauty of the forest are the orchids, of which there are more than two hundred kinds, rich in colour and variety of form. At 4,500 feet above the sea we reach the upper limit of the cultivation of indigo, cacao, coffee, and cotton, while the sugar-cane, banana, and the American pisang (*Heliconia*) ascend some hundreds of feet higher. The climatic change is more keenly felt at the foot of the Cordilleras, at a height of 5,640 feet, where the tropical forms of vegetation begin to disappear. Here fertile maize fields are spread out before the traveller's gaze. Delicious anonas, pomegranates, lemons, and oranges thrive side by side with peaches, apricots, apples, pears, and special kinds of walnuts; and as the fruit trees of different zones are here found together, so it is with the shrub growths; blackberry bushes, melons, different kinds of sage, St. John's wort, creeping gourd plants (*Sicyos*), crown the ridges of the maize fields, but pineapple growths, *Yucca gloriosa*, together with wild vine, pepper plants, passion flowers, and

GATHERING THE COCHINEAL from the *Opuntia Coccinellifera*. In foreground to the right a female insect (natural size). Above the plant two flying male insects, the second natural size.

other lianas, are found among them. Three hundred feet higher appear the arum growths (*Pothos*), bignonias, and dahlias (*Georgina variabilis*), those beautiful flowers and leaves which we owe to America, and in part to Mexico. With every further advance the forms around us change, although the general character of the landscape remains unchanged. At 5,850 feet we find lupins, and fuchsias and orchids prevail as far as 6,600 feet. At 6,390 feet we meet with the first conifer (*Pinus leiophylla*), and from this point until 10,350 feet, our path lies between the most magnificent pine woods, almost entirely composed of special forms of conifers. Nothing here recalls the monotony of the northern non-coniferous trees; oaks and alders are found on all sides, together with a varied undergrowth of heaths and arbutus. But the glory of the forest is the splendid fir tree (*Abies religiosa*), which grows to a height of 190 feet, with a diameter of 15 feet. This solitary Mexican fir does not appear below the height of 8,457 feet. A little lower down we find the medicinal jalap (*Ipomœa purga*), a climbing plant with perennial tubers. The trees growing between 7,350 and 9,420 feet above the sea are generally clothed with the lichen, so common in America, and still higher up the mountain with a plant akin to our mistletoe (*Viscum vaginatum*). Maize culture ceases at a height of eight thousand feet, but not the tree-like growth of many grasses; millet-like forms rise to the crests of the laurels, which resemble oaks, and at 9,420 feet we are surprised by a lofty forest of bamboos twenty-one feet high. Near to the limit of tree growth (11,580 feet) are stevia, which represent our rhododendrons, and grow among the volcanic *débris* of the Cordilleras, between 10,350 and 12,810 feet above the sea, among alpine shrubs, groundsel and prickly bramble, and the stunted Montezuma fir. The soil, composed of the finer outpourings of the volcano, is covered on the highest level of the mountain with a grassy meadow, and on the rocky blocks of the crater, which rises 13,470 feet above the grassy plain, nothing is seen but mosses and lichens. To complete the view of this flora, we must say that in almost all the different regions up to 10,350 feet, the cactus is found; and that, out of its numerous species, only the parasitic leaf cactus, a species in which the stem assumes the flat shape of a leaf, and which is not known in the prairies, is restricted to the shadowy woods of the hot region.

Not indeed the most beautiful, but certainly the most valuable variety of cactus in a commercial point of view is the cochineal fig (*Opuntia coccinellifera*), on which is found the most important of all scale insects, the *Coccus cacti*, which when dried produces cochineal. Both plant and insect were originally natives of Mexico, but are now cultivated also in the West Indies and Teneriffe, as well as in Spain, Algiers, and Java.

Among the plants which we have not mentioned, but which are of some importance commercially, are two lianas, sarsaparilla (*Smilax officinalis*) and vanilla (*Vanilla aromatica*), a plant belonging to the orchid tribe. The mahogany tree (*Swietenia mahagonia*) and the guaiacum trees (*Guayacum officinale* and *sanctum*) also deserve notice. A taxodium (*T. mucronatum*) is remarkable for the shapeless thickness of its trunk. Even in the days of the Spanish Conquest, the tree of Tula, near Oaxaca, which has been compared to the African baobab, was an object of wonder to Europeans. According to recent measurements, its circumference five feet from the ground is given as nearly ninety feet.

To obtain an idea of the flora of Mexico it is only necessary to imagine the vegetation just described from the Orizaba as that of the whole country. The steep mountainous coasts of the Pacific are lined almost everywhere with unbroken mangrove forests, while the eastern shores are fringed by a belt of level, marshy, or sandy plains, averaging from ten to thirteen miles in width. These plains are, as a rule, destitute of vegetation. The plant life of the slopes descending toward the two oceans is the same as that of the Orizaba; it is richer in the Barrancas, the ravines which everywhere cut into the volcanic plateaus of Mexico, poorer on the more or less level plains, while in the highlands of the interior almost barren and treeless wastes abound, and with them are seen the high salt steppes, where the scanty water supply finds no outlet, and evaporates in inland lakes.

Thanks, however, to the presence of the mountains which rise from the plateau, and the streams of water which flow from them, a great part of the plateau is fertile enough to admit of the growth of trees and cereals, such as wheat, maize, and barley. The culture of the maguey (*Agave Americana*) is widely carried on, and the plateau climate is favourable also to the olive, mulberry, and vine.

The fruit trees of tropical America are of special importance. Here, as in all tropical countries, the banana claims a high rank. Although it is probable from philological grounds, and from the history of vegetable geography, that it came originally from Asia, the only continent where it grows wild and has native names, it has been long enough in Mexico to be found there as an object of culture by the first European visitors.

The place of the bread-fruit tree, which also belongs to the Old World, is filled in America by the papaw or melon-tree (*Carica papaya*). Like the banana, it is cultivated by the Indians near their huts, and by the negroes in gardens. Its home is in Jamaica, Domingo, Surinam, and tropical Brazil, whence it must soon have been transplanted to Congo and the East Indies; for as far back as the year 1626 its seeds were brought thence to Naples, and in later days it was introduced into China, Japan, and the islands of the Pacific Ocean.

One of the commonest fruit trees of America is the Guava (*Psydium pyriferum* and *pomiferum*), with fruits which look like oranges, but otherwise resemble pears and apples. This tree, which belongs to the myrtle tribe, is distributed from Mexico to Brazil, whence it has been transplanted to the West Indian Islands and to the East Indies. It is now cultivated also in China, the Philippines, on the west coast of Africa, and on the island of Mauritius.

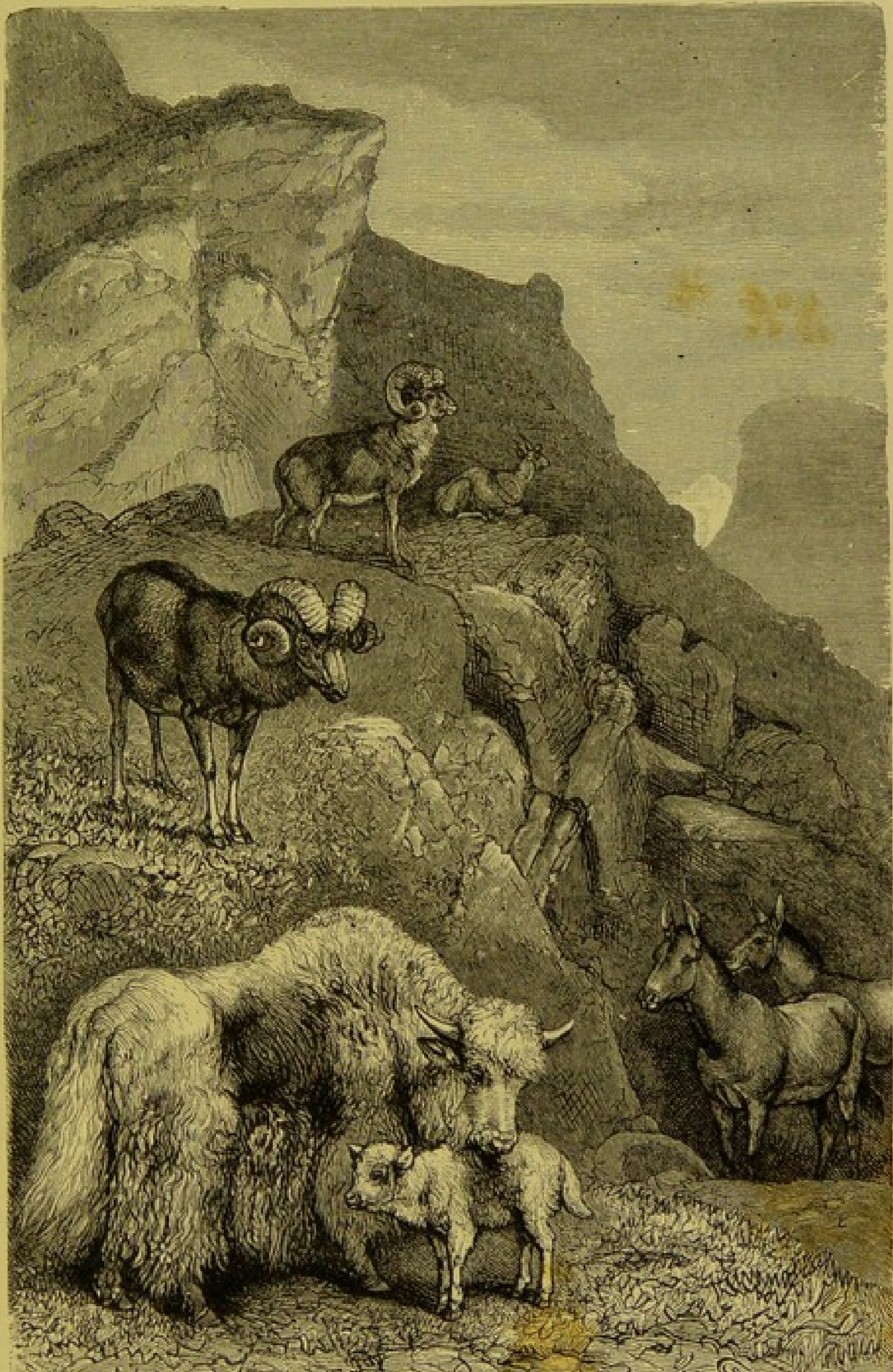
The medlar-like fruits of the sapota (*Sapota Achras*) are highly prized. They grow upon a tree forty-eight feet high, which is still found growing wild in the forests of Venezuela and a few islands in the Antilles. It is now transplanted to Java, the Philippines, and Hither India. A similar but larger fruit is found on the *Sapota mammosa*. Our plums are replaced by several kinds of Spondias, trees belonging to the family of the *Anarcardaceæ*, which are found both in America and the islands of Oceania; and by the Spanish plum (*Ibametra, Acacia, Spondias myriobalanus*), which grows wild in Jamaica, and is cultivated in the hotter parts of Brazil; also by the Mombin plum (*Sp. Mombin*). The Icaco plum (*Chrysobalanus Icaco*), which grows wild in the barren coast forests of equatorial South America and in Africa, from Senegal to Congo, comes from a plant akin to the almond growths.

A few species of Eugenias bear a fruit resembling a cherry; for instance, the *Eugenia Michelii*, introduced into Cayenne, and the *E. cauliflora*, cultivated both in the Antilles and the East Indies.

The genus Anona is the richest in fruit trees, all of which, with one exception (*Anona Senegalensis*), belong exclusively to America. The crown of all tropical fruits is said to be the *Anona cherimolia*, originally found growing wild in Peru, but now cultivated largely in Venezuela, New Granada, Brazil, Guinea, and in the Cape Verde Islands. The species most widely distributed and principally cultivated is the custard apple (*Anona squamosa*); its home is said to be the plain at the mouth of the Amazon; and Martius mentions having found whole plantations of it in Para, and it is very common in Mexico. Other species deserving mention are the *Anona reticulata* and *A. muricata*. One of the finest trees of the Antilles is the mammea (*Mammea Americana*). Its fruit has a delicious flavour, and measures from three to seven inches long. It is cultivated only in the West Indies and in a few places of Central America.

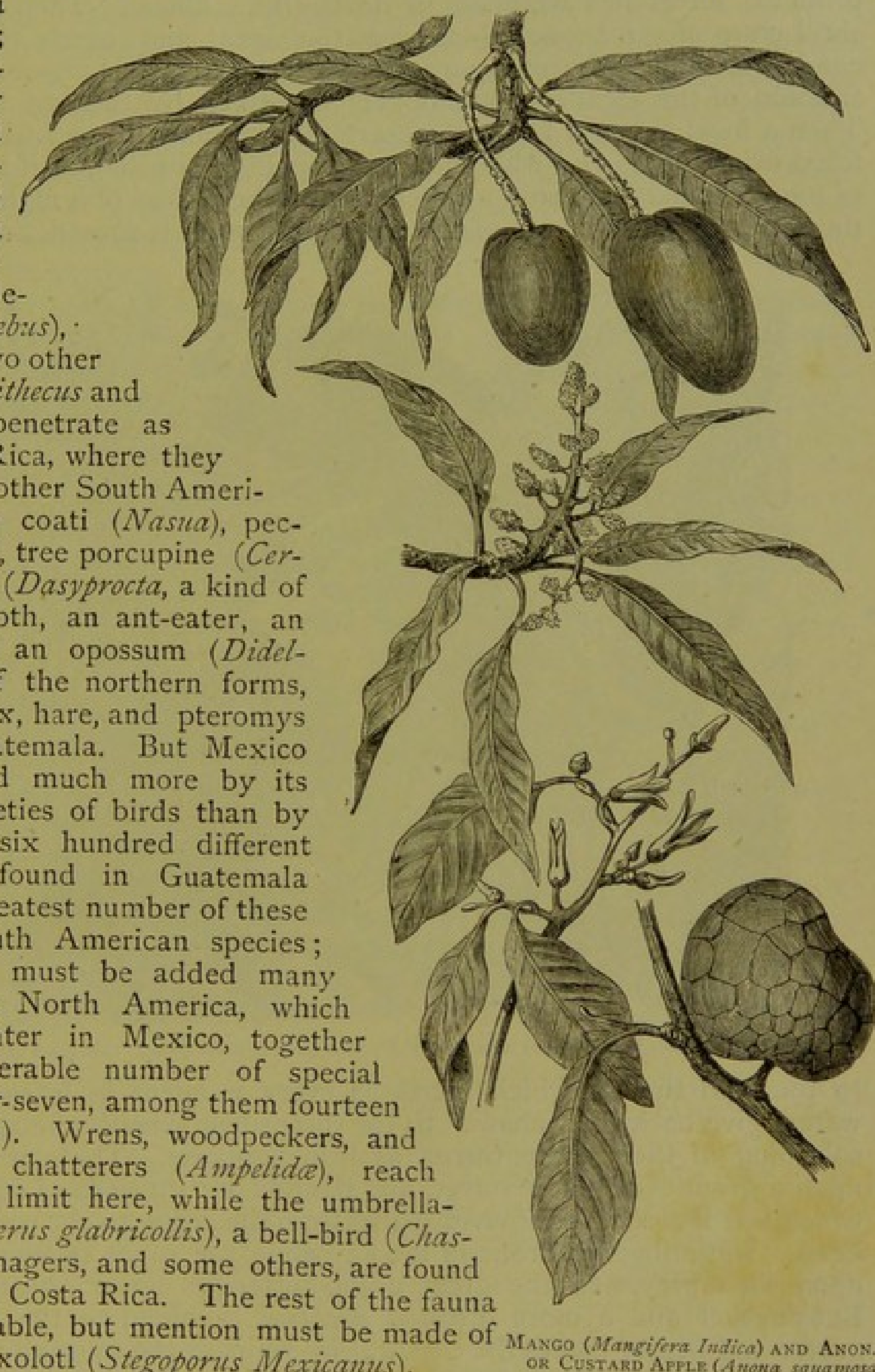
In Brazil the Aguacata (*Persia gratissima*) is considered the finest fruit of the country; it is like a choice eating pear, with a hard kernel resembling a walnut. Their home is Central America, the north of South America, and Mexico.

The acajou (*Anarcardium occidentale*) bears an edible pear-shaped stem. This tree has been recently introduced into the East Indies, its true home being the West Indies and Central America as far as Brazil.



YAK, ARGALI AND KIANG.

As the flora of the prairies gradually changes into that of the terra fria (cold region), its animal life also penetrates far into Mexico, where its last representatives combine with the South American fauna to make up a strange and unique picture. Of mammals it is true we find only two special forms—a tapir and a kind of mouse; but the howling monkey (*Mycetes*) and the spider monkey (*Ateles*) are found in Mexico, while the prehensile-tailed ape (*Cebus*), together with two other species (*Nyctipithecus* and *Pythesciurus*), penetrate as far as Costa Rica, where they are found with other South American forms, the coati (*Nasua*), peccary (*Dicotyles*), tree porcupine (*Cercolabes*), agouti (*Dasyprocta*, a kind of guinea-pig), sloth, an ant-eater, an armadillo, and an opossum (*Didelphis*); while of the northern forms, shrewmouse, fox, hare, and pteromys extend to Guatemala. But Mexico is distinguished much more by its numerous varieties of birds than by its mammals, six hundred different kinds being found in Guatemala alone. The greatest number of these belong to South American species; but to them must be added many migrants from North America, which spend the winter in Mexico, together with a considerable number of special varieties (thirty-seven, among them fourteen humming-birds). Wrens, woodpeckers, and the beautiful chatterers (*Ampelidæ*), reach their southern limit here, while the umbrella-bird (*Cephalopterus glabricollis*), a bell-bird (*Chasmarhyncus*), tanagers, and some others, are found as far north as Costa Rica. The rest of the fauna is less remarkable, but mention must be made of the Mexican axolotl (*Stegoporus Mexicanus*).



MANGO (*Mangifera Indica*) AND ANONA, OR CUSTARD APPLE (*Anona squamosa*).

Thousands and thousands of parrots of all sizes and colours, from the dignified arara to the impertinent loxie, myriads of flame-coloured brilliant humming-birds, troups of pepper-eaters, with their long colossal bills, snow-white garcias, whose downy plumage is a favourite adornment of ladies' hats, have all agreed to hold their rendezvous on the outskirts of the vegetal region bathed by the Lake of Nicaragua. How numerous and rich the fauna must be, is shewn by hundreds of quadrupeds, from the roe to the armadillo, bands of little monkeys and squirrels clambering down to drink from the water's edge, and splendid butterflies as large as a man's hand. But before us the primeval forest lies wrapped in death-like stillness. Then all at once the shrill chirp of some lonely bird gives the signal, and sounds the first note of a concert as wild and grotesque as the forest itself. The long-continued, piercing tremolo of the cicada (grasshopper) is broken by the low hoot of the owl. Then a howl is heard from a solitary quarter, and in an instant the forest is filled from end to end with the most appalling howling, as if the whole rabble of monkeys had suddenly awakened from the terrors of a nightmare. By this time the jaguar, monarch of the southern woods, is roused, and his howls add

PARROQUET (*Sittace*) AND GIANT TOUCAN (*Ramphastus Poco*). One-tenth natural size.

to the wild tumult, which increases every moment in intensity. Even the waters give back their answer to the discordant *reveillé*, the alligators heavily splashing in their contentment, as if in applause. The stars, glittering as if upon a ground of black velvet, are rivalled by myriads of fiery glow-worms, which rise like sheaves of vivid sparks from the sedge to the roof of leaves overhead. Large beetles drone in the air, while the night swallows pounce down upon their prey, and the great night-butterflies hover ghost-like in the air. But another and a more dreaded *nocturne* is added to the terrific concert; nearer and nearer comes the penetrating whirr of the mosquitoes, and beneath their venomous sting the enthusiasm of the European naturalist soon dies away.

THE WEST INDIES.

The West Indies possess a number of climatic divisions united within a narrow space. The sun in these regions twice attains the zenith in his annual path, and the rainy season which follows is generally divided into the longer season, which lasts from August till the end of November, and a shorter one in the spring. On the tropical circle itself both these seasons coincide, and the rain falls only once, and in the summer.

In the Greater Antilles the solstitial rains are of shorter duration, because of the higher latitude; but independently of the position of the sun, the trades disburden themselves of their abundant moisture when they descend vertically upon the northern side of the mountains, and blow up along the face of the slopes. And even in other seasons of the year they bring rain, and clothe the hills with their robe of forest green; while on the south side, in Jamaica, for instance, we find a Savannah climate, with its clusters of trees and grassy plains adorned with thickets.

The Western Caribbees have a long rainy season, the Eastern Caribbees a short and scanty one. Upon the former islands the rain falls upon closely wooded volcanic heights, while in the small level plains of the Eastern Caribbees trade-winds drive away the rain-clouds before they can discharge their showers.

The Bahamas are flat islands extending partly beyond the tropics into the latitude of Florida, and, like the opposite coast, enjoying heavy summer rains; but notwithstanding the nearness of the continent and the similarity of its climate, they do not participate in its flora. Moreover, in consequence of the higher latitude, the temperature of the Bahamas is less uniform than that of the remaining island groups, where the annual fluctuations of temperature are so slight as not to affect the vegetation; even on the tropical circle at Havanna the temperature is not nine degrees warmer in summer than in winter, and the annual heat of the coast region remains nearly the same (77° to 82·5° Fahr.) throughout the whole circumference of the West Indies.

Agriculture has introduced into the vegetation of the West Indies changes as important as those experienced in the cultivated countries of the Old World. In the west of Cuba two-thirds of the land is under culture, and scarcely one-third consists of forest and pasture land. The savannahs upon which cattle are bred are no longer found in their original condition, but have been improved by the introduction of the Para and Guinea grasses (*Panicum maximum* and *molle*). At the time of the discovery of America almost the whole of Jamaica was covered with forests of mahogany trees and cedrelas (*Swietenia* and *Cedrela*), the so-called cedar wood of which cigar boxes are made. The native races, who have long since disappeared, understood no culture but that of maize; in later times sugar-cane was the chief object of cultivation in the lower region (up to 2,625 feet above the level of the sea), while coffee plantations were introduced upon the mountains from 2,625 to 5,250 feet. Besides these plants, cotton, tobacco, and cacao were largely grown, and with highly satisfactory results. Since the emancipation of the slaves, large tracts of pasture land have taken the place of cultivated ground; notwithstanding which the aspect of the West Indies preserves in its principal characteristics the appearance of an archipelago wooded up to the very summits of the mountains; for the culture itself consists partly in tree plantations, the settlements being accompanied by orchards of fruit trees and palms, and the savannahs containing clusters of trees. Besides this, the tillage of the ground, as is the case in all tropical countries, is followed by an after-growth of shrubs and trees when the ground is left to itself. In the primeval forests the forms of vegetation belonging to the warmer regions of tropical

America are still found together. The prevalent tree forms, with the leafage of the olive or the laurel, appear in an unusually diversified blending of families. The palms are not so numerous as upon the continent. Fan-palms (*Thrinax*) are the commonest, but almost all the trees of the primeval forest are overshadowed by the famous cabbage-palm, and by the royal palm of Havanna (*Oreodaxa oleracea* and *O. regia*), which attain the height of 112 and 103 feet respectively. The drier sea-coasts are fringed by cocoa-palms, and the lagoons are filled with mangrove forests. Tree-ferns are not found below a certain height above the sea level; they sometimes combine in the mountain forests, and form an independent growth, rising higher than upon the continent (282 to 5,250 feet). On lower levels they grow scattered throughout the shadowy forest recesses, accompanied by the smaller palms, bamboos, and the American pisang (*Heliconia*). The genuine bamboo (*Bambusa*) is of East Indian origin, but has been widely dispersed by cultivation; the allied West Indian forms vary in the formation of their blossoms, but not in their growth. One of them (*Arthrostylidium excelsum*), a native of Dominica, grows seventy-five feet high; another in Jamaica (*Chusquea abietifolia*) climbs as a liana among the crests of the trees.

Many trees growing upon the islands and the mountain-sides, which are not exposed to the influence of the trades, lose their foliage in the hot season. Forms with feathery leaves are more common here than in the primeval forests: meliaceæ, sapindaceæ, terebinths, leguminosæ, especially mimosas, and in many places, for instance in Jamaica, logwood (*Hæmatoxylon campechianum*), and lastly palms. From those regions where there is less moisture we obtain from the native plants guaiacum, gum, the caranna resin from *Bursera*, and mahogany.

The most imposing of all the West Indian trees is the cotton tree (*Eriodendron anfractuosum*), so called from the downy covering which envelopes its seeds. It grows to the height of 144 feet, the trunk being equally thick to the crest, and is distinguished by wide wing-like branches projecting from the ground to the height of fifteen feet. Its position upon the chalk mountain belonging to the tertiary formation on the slope, exposed to the trade-winds, is also shared by the aromatic pimento tree (*Pimenta vulgaris*), the fruit of which comes into the market as allspice or Jamaica pepper.

Conifers are found in Cuba, but are restricted to that place, the neighbouring island named *Pinos* after them, Haiti, and the Bahamas.

The most numerous of the native shrubs are the madder growths, myrtles, melastomaceæ, and wolf's-milk tribe (*Croton, phyllanthus*). In the mountains are found several heaths with myrtle-like foliage. The form of the dwarf palms (*Sabal, copernicia*), to which a few cycads (*Zamia*) must be joined, is found along the rocky coasts as far as the Bahamas.

Lianas and epiphytes abound. In the primeval forest prevail the true epiphytes, with woody stems; their growth is luxuriant, and they enfold the trees like a network. In drier climates the liana form prevails, because when the ground is clearer and sunnier, the woody stem can be dispensed with. As a rule, the influence exerted by the duration of the rainy season is seen most clearly in the epiphytes. In the Savannah climate, the trees serve as a support for the growths of the cactus and bromelia tribes; they are often robbed of their sap by loranthaceæ and fibrous parasites, for instance, cassyta. Even on the immense cotton tree are often seen those figs (*Ficus pertusa*), which cling round the stem with their aerial roots, stifling it in such a manner as to explain the saying, that the Creole is suffocated in the embrace of the

Scot. Upon the trees of the humid forest the fern forms prevail. With the lavish play of their leaf outlines they look like living arabesques upon the columns of the leafy vaults. Colossal forms, the rosettes of which are sometimes more than a yard wide (*Gymnopteris, Polypodium aureum*), down to the diaphanous tissue of the exquisite trichomanes, which resemble mosses in their size and delicacy. Lastly, the atmospheric orchids are represented both in moist and in periodically dry air, but by unequal forms.

We should trespass beyond the limits of this book were we to mention in more detail the produce of the West Indian islands in coffee, sugar, tobacco, cotton, arrowroot, indigo, sarsaparilla, cacao, pimento, ginger, annoto, obtained from the *Bixa orellana* which grows wild in the Antilles, cedrela, mahogany, and logwood; it must suffice simply to name them, together with cochineal, wax, honey and skins.

As the four larger islands are, when taken together, larger than Great Britain, we may expect to find that they contain an imposing and luxuriant fauna. The contrary is however the case, and there is perhaps no land upon the earth which is so favourably adapted by nature to contain a rich animal life, and at the same time so poor in all the higher organised forms of animals.

The mammals are especially few in number. Almost all the orders which are characteristic of South America are wanting here. There are no oxen, no carnivora, no edentata. Only two orders are represented, besides the bats, of which there are very many, rodents, and insectivora. Among the latter are the solenodon, animals of the size of a cat, with long snouts like that of the shrewmouse, bare rat-like tails, and long claws, which have kindred forms nowhere else but in Madagascar. It is said that seals appear near some of the islands, but are very little known.

Two hundred and three kinds of birds are at present known, to which must be added eighty-eight North American birds of passage, which either spend the winter in some of the islands, or pass over into Central or South America. The 203 kinds belong to ninety-five distinct families; and of these, 177 kinds and thirty-one families are restricted to the island world. If we reflect how near the islands lie to the mainland in many places, the number of exclusive kinds just given is, perhaps, absolutely unparalleled in any other part of the globe, especially in reference to such wandering little creatures as birds. The most interesting of the exclusive species are four thrushes, two tanagers, two trogons, five humming-birds, two cuckoos, two owls, and lastly, the todies (*Tordus*). The non-exclusive families include, among others, the following exclusive species, nine parrots, sixteen humming-birds, ten tanagers; and this is the more remarkable, because the four largest islands probably possess no more than half a dozen common species, and shews an isolation and specialty probably unequalled anywhere else.

Sufficient study has not been devoted to the remainder of the vertebrate fauna; but it exhibits in some respects similar features to those of the bird world, a general tendency to South American forms, a more decided tendency to those of Mexico and Central America, and a considerable number of exclusive forms.

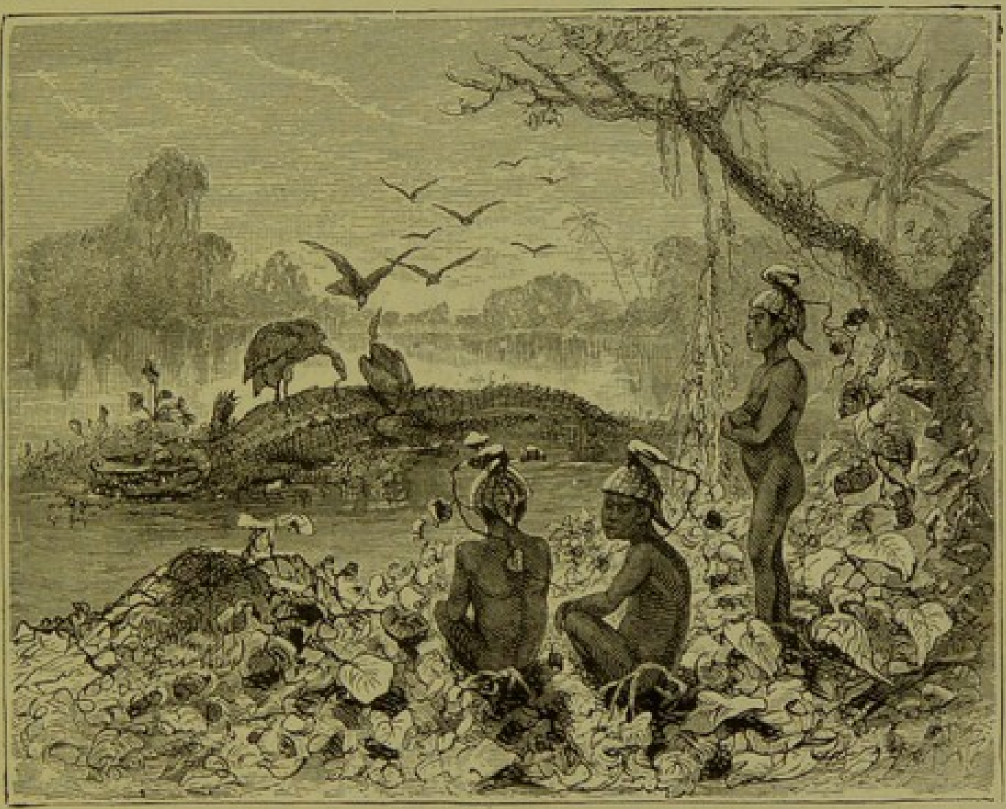
The different West Indian islands have not yet been sufficiently explored with regard to insects, as their comparative poverty renders them little attractive to professional collectors, especially as the inexhaustible treasures of Central and South America are so near at hand.

The riches of the West Indies in land snails is most extraordinary, and, as we said of its birds, has no equal in any other part of the world. There are already forty families known, containing 1,345 species, while the whole American continent contains only thirty-six families and 1,402 species. And yet we are forced to suspect that many species have become extinct since the country was taken possession of by Europeans. In Santa Cruz, many species have perished within a comparatively recent period, owing to the burning of the forests; and as we know that upon all the islands many species are restricted to certain well-defined localities, often to isolated valleys or the ridge of some solitary mountain, we may be sure that wherever the primitive forests have been destroyed by the hand of man, many land snails have perished with them. How many species or even families may have been lost in this manner we cannot even guess, for the wealth of land snail is very unequally distributed throughout the archipelago. Trinidad possesses only twenty families and thirty-eight species, while Jamaica has about thirty families, and more than five hundred species.

South America North of the Equator.—New Granada, Venezuela, Guiana.

The territory of South America on the north of the equator, as represented upon our charts, receives along its whole extent of coast a refreshing, constant, and moisture-laden sea wind, and as nearly the whole stretch of coast is mountainous, the rainy season lasts long enough to ensure a splendid forest vegetation. But the interior of the continent, on the other hand, where lie the great savannahs of Guiana and Venezuela, the boundless llanos so geographically described by Von Humboldt, is visited by sudden contrasts of dry and rainy seasons, depending upon the position of the sun. Here the influence of the sea is checked because the mountain chains and forests withdraw the moisture from the ocean winds. As long as the north-east trade-wind prevails, there is uninterrupted drought; the savannahs appear parched and lifeless, and not until the sun's position in the heavens transfers the heat centre to the plains themselves, does the south wind, blowing from the humid equatorial forests, bring in the rainy season, which renews the life of the plant world.

In order to learn the full splendour of the rich vegetation with which this region is covered, we will choose, from among the many paths leading into the interior of the country, the river Magdalena, following the guidance of the traveller and naturalist, E. Andrés. The first view of the scenery is magnificent; for while the coast itself is veiled by streaks of cloud, or the tremulous shiver of the heated air, the snowy peaks of the coast mountains rise majestically against the intense blue of the sky. But if the traveller happen to land near Salgar, not far from Sabanilla, the scene is changed, the light and colour are vivid and unfamiliar; and yet the spectator is disappointed, for instead of encountering a stretch of luxuriant vegetation, he is received by a sandy desert. The glare of the sun is intolerable, and little coolness is obtained from the stormy blasts of wind which blow incessantly night and day. A few shrubs, cassia, jatropha, and the tall cactus (*Cereus*), make up the scanty vegetation of the sandy coast, the home of the green and grey lizards. But in journeying up the stream this inhospitable scene is quickly exchanged for other pictures. Sitting upon the deck of the steamer, if the heat is not too great (and it is generally about 127·5° Fahr. on the sandy shore), refreshed by the gentle breeze, he looks for hours together upon the silent waters and the virgin forest, from whose tree-crests the green climbing plants wave downward to the surface of the river. Motionless, giant alligators lie along the water, on the watch for any refuse thrown from the deck of the steamer, or any man who may have the ill-luck to fall overboard. Numbers of these dangerous creatures crawl along the shore, presenting a welcome mark for the rifles of the passengers. If one of the alligators is wounded, it generally has time enough to crawl down to the water, and end its life beneath the waves. A week later the carcase, inflated by gases, rises to the surface. Water plants (*Pistia* and *Pontederia*) light upon it, and before long the vultures (gallinazos) collect round the unexpected booty. We turn toward the shore for a pleasanter picture, and see the aristolochia, or birthwort, one of the most curious plants of South America, related to our mock-orange, with heart-



DEAD ALLIGATOR. On the shore native children with blossoms of the Aristolochia on their heads.

shaped leaves (*Aristolochia clypeata*), clinging to the trees, covering them with its glossy leaves, and adorning them with colossal blossoms. These flowers are so large that the naked children are often seen walking about with a picturesque Phrygian cap, straw coloured, and splashed with violet, for their sole clothing, which proves to be neither more nor less than a blossom of the aristolochia.

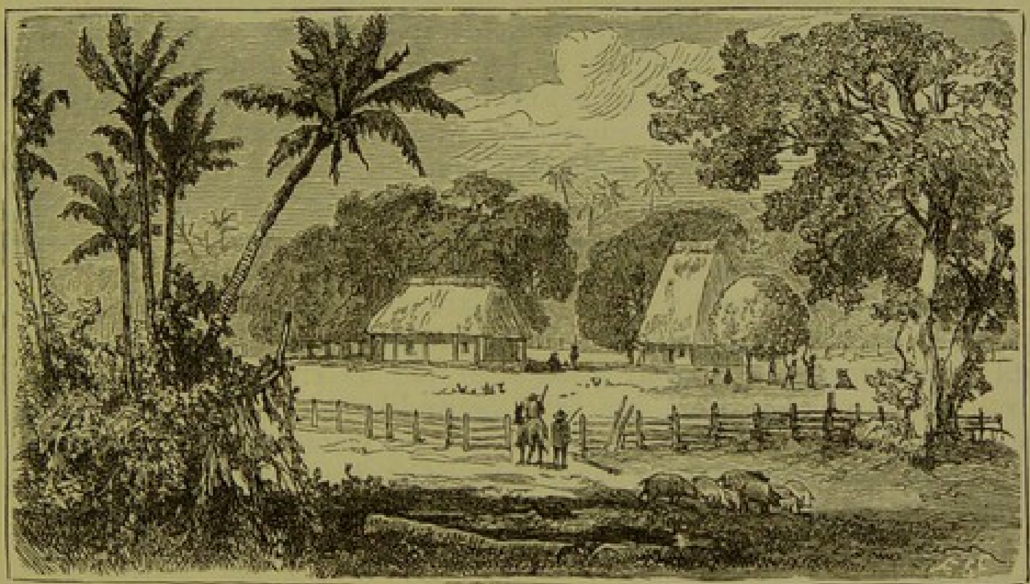
Whenever the steamer stopped to take in a supply of fuel, André went on shore. With rifle on his shoulder and a short stick in his hand, he entered the untrodden forests with cautious steps. He had been warned against snakes, and carefully examined the shrubwood; but on seeing the grass move, and hearing a low, bellowing noise behind him, he captured nothing more deadly than an innocent bull frog (*Rana mugiens*). Where the great woods extended to the water-side, troops of great white herons, wild geese, the curious gallinaceous fowl Penelope, and the black-plumed curasson (*Crax*), with its orange-coloured protuberance at the root of its bill, met together. Myriads of parrots, especially the small chattering paroquet, lighted upon the giant trees; yellow, black, and blue tanagers, and the brilliant pharomacrus, gorgeous in plumage of emerald and ruby lustre, filled the sportsman's bag. Large herds of peccaries (*Dicotyles torquatus*) played in the open glades of the forest. The path led between walls of banana-like growths (*Helicona* and *Phrynium*), whose leaves, shaped like gigantic oars, shut out the light of day. Philodendron, with split, hand-shaped leaves, climb up the tallest trees, and when André fired at one, the red cylindrical clump of blossoms, measuring fifty inches in diameter, fell crashing down upon him. In Puerto Nacional (8° N. lat.), the traveller attempted to gather the branches of the palo santo (*Triplaris*), a tree belonging to the knotgrass tribe, when he suddenly felt a pain like that caused by the touch of red-hot iron, and stood for a few minutes stupefied by some animal venom. When he recovered himself, and examined the tree more closely, he found a large ant, of a light, rusty-brown colour, which burrows in the bark of the tree, and at the slightest touch to the trunk rushes out to attack the enemy. It is to the fear inspired by this venomous insect that the tree owes its name of "sacred." Not far from the Straits of Naxé (lat. 6° N.), the shore is covered with bamboos and a number of lianas, among which are several ipomæas and passion flowers. In some places the coast is torn and devastated by the water, and covered with a chaos of dead wood and fallen trees half under water. From the deck of the vessel several kinds of snakes can be seen moving to and fro among the confused heaps, and the natives say that the bite of some of the reptiles is deadly enough to cause the death of a man in a few minutes. All of them, however, flee from the hunter, and it was with difficulty that André captured one specimen of the elaps or coral otter. Beautiful land aroids (*Diffenbachia*), and new aristolochias attract the attention of the traveller. Giant crooked fig trees, 150 feet high, spread abroad their wide roots, partly above, partly below the ground, while from their branches hang the long, grassy, pouch-like nests of the starling, which give such a peculiar aspect to the scene. Within these forests the basilisk famed in many a fable (*Basiliscus mitratus*) darts from tree to tree to capture its insect prey, and is found to be a mere harmless lizard, common in Guatemala. The air is full of the cries of parrots, among which the large aras are most conspicuous by their flame-coloured or blue and golden plumage, and by their always flying in pairs. Parasitic *Loranthaceæ* cling to the branches of the trees, tiny orchids (*Mesospinidium*) appear for the first time, and in the night the weird concert of the howling monkeys breaks the silence. The wealth of nature is overpowering, and only the human life is low and poor. Huts are seen upon the banks of the bounteous river. The walls, where they are found at all, are made of split bamboo cane; four stakes support the roof of banana (*Helicona*). The whole inventory of household furniture consists of a blow-pipe to kill small birds, a few mats, some fishing hooks, three stones to support the cooking saucepan, and an old gun. Within this dwelling, man, wife, and children exist in constant idleness. Their food is supplied by a few fruit trees, bread-fruit and melons, manioc and batata, with now and then a meal of game or fish. The luxuriance of the vegetation relieves them from all necessity for work; the coffee plant grows everywhere, the orange tree yields a never-failing supply of its golden fruit; and, without the aid of human labour, the gourds twine round the neighbouring trees, and furnish pitchers and dishes, while the sugar-canes last for a quarter of a century without having to be renewed. But all this lavish wealth is left unused, and not a trace of culture can be seen. The grown men never work, or at the most only gather the fruit of the ivory palm (*Phytelephas macrocarpa*), and exchange its treasures of vegetable ivory for brandy brought by the traders in the steamboats. The children eat earth, and suffer in consequence from a frightful distension of the stomach. At last the steamer reaches Honda (5° 11′ N. lat.), the staple market for the produce of the neighbourhood, and the European goods intended for Bogota. Among the former, the tobacco brought from the town of Ambalemba holds the first place in importance, and next to this the following are the chief products of the surrounding countries:—Maize, potatoes, beans, corn, rice, bananas, aniseed, cotton, sugar-cane, coffee, and vegetable ivory. The forest contains logwood (*Hæmatoxylon campechianum*) and other beautiful dyeing woods which are little known in Europe. (Morcate and jengibrillo give a yellow dye; chirca, green; bagala, lilac; and tagalagua, dark blue.) The *Bixa arellana*, and valuable timber trees, such as the mahogany tree (*Swiecenia mahagoni*). Lastly, various medicinal and balsamic plants, of which the natives tell the most wonderful stories concerning their properties; among them sarsaparilla, copaiba or balsam of tolu (*Myroxylon Soluifera*), frankincense, turpentine, and the fragrant aromatic vanilla.

VEGETABLE IVORY TREE (*Phytelephas macrocarpa*). Heliconias to the right in the foreground.

The fauna, like that of all other South American countries, is poor in mammals. The most remarkable are bears, apes, jaguars, pumas, wild cats, foxes, bears, tapirs, peccaries, rabbits, squirrels, sloths, and ant-eaters. The troops of birds are innumerable, and we have already mentioned many of their leading representatives. As for the fish tribe, a wide field is waiting for the research of the naturalist, for as yet little is known of this section of animal life. The same may be said of the numerous and very dangerous snakes, lizards, and tortoises. Countless, too, is the number of insects, mosquitoes, ticks, bugs, and ants, which haunt the traveller's memory as contributing to the least agreeable experiences of his journey up the Rio Magdalena. Besides these creatures, cochineal is found on land, and pearls and coral in the sea near Rio Hacha.

And now we bid farewell to Honda with its singularly high yearly temperature of 81° Fahr., a climate seldom found 630 feet above the sea, and ascend to Bogota, more than 7,200 feet higher still, which brings us into the region of the tropical Andes. The ascent of the Cordilleras begins in the immediate neighbourhood of Honda. The vegetation of the tropics makes way for that of the temperate zone; the *Aralaceæ japonica* (jalap), several kinds of orchids, laurel growths, plants akin to the bread-fruit tree (*Arto carpeae*), and a charming helmet plant (*Scutellaria*), with clusters of vivid scarlet blossoms. Whole forests of bamboos are seen in the neighbourhood of Guadnas, to which they give their name, and the ground is carpeted with the wild strawberry (*Fragaria vesca*), which daily fills the markets of Bogota. At the right moment the traveller comes upon a hut roofed with palm leaves. The bread flavoured with caraway seeds excites the thirst, and the hostess brings in a large vessel, made of bamboo, the welcome draught of guarapo, a kind of lemonade, and offers the refreshing beverage in a calabash made of the half of the hollowed-out fruit of the calabash tree (*Crescentia cujete*). At the height of 2,517 feet the way leads past numerous sunny plantations of sugar-cane.

Still ascending, we reach the *terra fria*, or cold zone, at the height of about 7,200 feet. Its vicinity is announced by a grey mist. From the trees hangs down a long white and grey fibre, the so-called tree-beard, American moss, or vegetable horsehair (*Tillandsia usneoides*, *Barba de Palo*), and sways to and fro in the wind. The plant growth is stunted and shrub-like, heaths of different kinds prevail (*Pernettya* with white bells, *Thibaudia* and *Macleania*, with salmon-coloured leaves), but other plants are also found, particularly sage, fuchsias, a sword-lily, and several other herbaceous and grass-like plants. Above this undergrowth rises the cruciferous *Senecionide*, with its red leaves and blossoms, which is sold in Bogota under the name of arnica, and used for healing wounds. The appearance of the vegetation, as a whole, is exceedingly characteristic, and by no means resembles that of our temperate zone; it shews the transition from the semi-frigid zone into that of the Paramos, the mountain meadow lands below the snow-line. At length the height of 7,890 feet is reached, and the traveller finds himself at Facatativa, upon the high table-land of Bogota. The plateau extends before him farther than the eye can reach; a short, close grass covers the ground, and serves as pasture for numberless herds and flocks of oxen and sheep of moderate size. Not a tree relieves the monotony of the plain; even the few houses met with at the intervals of long hours of riding have scarcely a tree or shrub to shelter them, for few trees can thrive at such a height above the sea. The cherry tree (*Padus capollin*), with its small, black, tasteless fruit, is seen near the *Polymnia*, or fool's tree, which owes its name to the fact of its being absolutely useless, and the solitary willow (*Salix Humboldtii*). Along the watercourse which intersects the single pasture grounds we find but little brushwood; but what there is, is encircled by charming lianas (*Tacsonias*) and a kind of gourd (*Cyclanthera explodens*) whose prickly fruit bursts with a loud snap under the pressure of the fingers. The water is covered with Azolla (*A. magellanica*), a beautiful herb, glossy as satin, and of a delicate green and red colour. The wide savannah is the playground of a solitary bird, the Andes sparrow, a trustful little creature, distinguished from our sparrows by a small mobile hood. In the gardens of Bogota, potatoes are cultivated, but they yield only a scanty crop; cabbage is also grown, together with artichokes, teazel, red, yellow, and white sorrel (*Oxalis tuberosa*), bearing a fruit like a potato; green onions, garlic, green peas, beans, endives, polymnia edulis, a small tasteless bulb, with medicinal properties; sweet vetch, pumpkins, marjoram, and culantro, an umbelliferous plant with a fœtid odour, and used for seasoning. In isolated ponds, a fish peculiar to this region is found (*Eremophilus Mutisii*), which is delicate in flavour. In the markets of Bogota, besides the plants and vegetables just mentioned, all kinds of roots and herbs are met with; such as azafran, the yellow root of a plant akin to water-betony, and used in all sauces; and the Ochuba berry, a kind of green, hard fruit, growing like a peach, which does not ripen here. To this list must be added, all the productions of the tropics, which the heat allows to thrive here—oranges, bananas, pineapples, cocoa-nuts, the fruit of the *Mammea Americana*, papayas, the fruit of the melon tree (*Carica papaya*), maize, tomato, Spanish pepper, manioc, and batatas. And how cheap everything is! An immense delicious pineapple only costs one penny.



HACIENDA CUMARÆ.

Before laying out a plantation in the tropics, a tract of forest land is fired—the proceeding is called *desmonte*—and from this naturally rich soil, fertilized still more by the burning, a fine crop of maize is reaped in three months. The grain is used as fodder for the herd of half-wild cattle which roam through the savannahs. After this, the same plot of ground is planted with bananas, coffee, and cocoa trees. In mountainous districts, an artificial meadow is made, and sown with two kinds of extremely succulent grass, namely, guinea grass (*Panicum maximum*) and para grass (*Panicum molle*), which are found distributed throughout South America. As long as these plants are young, they afford good pasturage; when they become hard and old, the meadows are fired, just before the rainy season, and given back to the cattle fourteen days afterwards. "The view from the verandah of the Vanguardia station," says a traveller through these regions, "was charming. In the yard, surrounded by stabling and maize fields, the poultry fought for their food with the wild birds from the forest. The heads of the cattle, were just seen above the top of the rich grass of the meadows, overshadowed by beautiful clusters of Unamos palms, which alone survived the burning of the forest, and contrasted sharply with the still standing, but blackened, trunks of the other trees. Rich fields of manioc (*manihot utilissima*) and maize shewed the rare fertility of the soil, which was heightened yet more by the rushing stream flowing by at some little distance. A separate enclosure was planted with all kinds of tropical fruit trees, and another contained medicinal plants—Hobo, with plum-shaped, sour fruit, used as a remedy for wounds, like the leaves of cordoncillo tacai, whose almond-like fruits yield a good oil;

the balsamic copaiva (*Copaifera*) and tolu (*Myrospermum toluiferum*), and in the neighbouring woods grew sarsaparilla, cinchona, caoutchouc, and ipecacuanha, which would soon be added to those already cultivated upon the farm."

Venezuela was explored in 1876-7 by Dr. Carl Sachs, who writes that the road from La Guayra, "the hell of Venezuela," and at the same time the harbour town for Caracas, abounds in beautiful scenery. The distance between the two places horizontally is only six miles, and along this tract the traveller ascends from the coast to the crest of the mountain (4,710 feet), and thence down again to Caracas (2,550 feet). Along the first 1,800 feet of the ascent stand giant cactus trees (*Cereus*) from thirty to thirty-eight feet in height, with trunks as thick as the body of a man, and branching candelabra-like growths; between them on the roadside are large bushes of long-leaved prickly agaves and opuntias; from the hot walls of rock springs the melon cactus (*Melocactus*), and the mammillaria seek for shady nooks. Gradually this scrub makes way for more familiar trees and flowery bushes. Evening closes in, bright-coloured butterflies hover round the bushes, and the harmless grasshopper begins its song hidden in the densest bush. Suddenly, almost without an interval of twilight, the night comes down; a deafening concert of insects, pitched in incredibly high tones, fills the air, and myriad glowworms trace their lines of fire through the darkness. Far below them lie the lighted plains of Caracas. From that place Dr. Sachs journeyed to Calabozo, where he intended to study the electric eels. The mule which he purchased for his journey cost £32, but this high price was asked in consequence of a disease which had broken out among the horses and mules of Venezuela in 1843, and had wrought such havoc among the large herds which roam through the llanos as to leave but few remaining. As if in farewell greeting to the traveller as he prepares to leave for the steppes, the vegetation of the border-land developes all its luxuriance at this point. Beautiful and stately trees rise on either side the road, and among them are seen many kinds of much value as building wood, and two which are famed for the healing juices or medicinal substances obtained from them. The copaiva tree (*Copaifera officinalis*), which yields the precious balsam of copaiva, grows there near the tacamajaca (*Icica tacamahaca*), from which, when the bark is pierced, the gum known as elemi is obtained.

On the ridge of the last promontory of the Andes chain the traveller suddenly observed a palm with greenish-yellow fan-shaped crown, and stem eighteen to twenty-four feet high (*Palma cobija* or *Copernicia tectorum*, also known as *Palma llanera*, or the Sombrero palm). Dr. Sachs had never seen it in the mountain districts, but he found it here in great numbers, and upon reaching the true llano, where the Sombrero palm appears in mass, recognised it as forming one of the most essential elements of the llano vegetation.

Another tree of great interest is the matapalo (*Ficus dendroica*), a parasite which chooses as its victim the slender stem of the cobija palm. In the strangest and most grotesque forms this marauder creeps among the plants, climbing generally in snake-like windings up the trunk of its prey, and raising its crown far above the summit of the palm. Sometimes, however, the matapalo shoots up in a straight line, and then sends out countless side shoots, which clasp tightly round the trunk of the cobija; and sometimes it has exactly the appearance of a tiger which has sprung upon its prey and thrust its claws into its body. The matapalo is strong enough to kill the tree upon which it has fastened, tightening its grasp more and more until it has penetrated deep enough to stop the circulation of the sap. But the iron strength of the copernicia palm proves sometimes a match for its aggressor. Comparatively few specimens were really killed, or had even yielded to the embrace of their murderer, and fallen into decay (which is a curious sight); the greater number stood erect, with all the glory of their leafy crown. Those palms which were entirely free from matapalo were generally marked with spiral lines throughout the whole length of the stem, and often so deeply cut as to have waists of truly wasp-like proportions. It was evident that these trees had been able to rid themselves of the importunate intruder.

Westward of the road by which Sachs travelled from the Cordilleras of the coast to Lake Maracaybo is found the singular palo de vaca (*Galactodendron Americanum*) or cow-tree. "I confess," writes Humboldt, "that of the many wonderful objects which have come under my observation in the course of my journeyings, few have made a stronger impression upon my imagination than the sight of the cow-tree. Everything which has to do with milk or the different kinds of cereals has an interest with us, which is by no means confined to the physical knowledge of these objects, but belongs to a wholly different order of ideas and impressions. We are hardly able to imagine how the human race can exist without farinaceous substances or the nutritious milk of the mother's breast, which is so well adapted to the child's lengthened state of weakness. The starchy flour of corn, which was an object of religious veneration among so many ancient people, is found in seeds and in the roots of plants, but milk appears to us always as an exclusive product of animal organisation. We receive this impression from our earliest years, and hence arises the astonishment with which we look upon the cow-tree. What impresses us so strongly in its presence is not the mighty shadow of the forest, not the majestic course of the river, nor the mountain peak frozen in eternal ice; a few drops of the juice of a forest plant brings before our inner eye the whole power and fulness of nature. By the naked wall of rock grows a tree about ninety feet high, with dry leathery leaves; its thick roots scarcely penetrate the hard road. For many months no drop of rain falls upon it, the branches seem parched up and dead. But when the trunk is pierced, there flows forth a stream of sweet, nutritious milk. The vegetable fountain flows most freely at sunrise, when the negroes and native tribes come from all sides with large bowls to receive the milk, which immediately becomes yellow and thick on the surface. One seems to see a shepherd distributing the milk of his flock among his people." The cow-tree is akin to the mulberry and the bread-tree, and next to it come two specimens of the *Apocyneæ* order, the milk-tree, and the hya-hya of the Indians (*tabernæmontana utilis*), a tree of Guiana, about sixty feet high. Although European plants do not yield drinkable milk in such abundance as to admit of their being tapped, we may yet mention the wholesome and nutritious milk of endives and scozonera, and the poisonous juice of the wolf's milk.

Sachs had expected to find a sudden and abrupt change between the wooded character of the mountain lands and the scenery of the steppes. But such is not the case. The fine trees which, upon the promontory, border the road as a dense wood gradually opened out into separate groves and clusters divided by grassy clearings. By degrees the tall trees are replaced by lower bush, principally composed of prickly mimosas (so-called *Dormideras*), with delicate feathery leaves, and generally brilliant with the most beautiful blossoms, not their own, but belonging to the climbing plants which grow upon them. After awhile the mimosas become gradually scarcer, until at length the boundless sea of grass stretches out to the distant horizon, unbroken except by clusters of copernicia palms, which rise here and there like scattered islets, and by the stunted growth of the chaparro tree. Humboldt's description of the llanos is written with such admirable truth and graphic power, that it only differs from the reality as seen at the present day in a few particulars. "There is," he writes, "something imposing, but sad and gloomy, in the monotonous aspect of the steppes. All within them seems frozen, and rarely is the passing shadow of a cloudlet seen crossing the zenith and announcing the approach of the rainy season upon the savannahs. I leave it undecided whether the first sight of the llanos or that of the Andes chain is the more striking."

The number of trees is not now so scanty as it was in Humboldt's day, and the "ocean of grass" described by him cannot be seen, except in the neighbourhood of Apure. In other places the greater part of the horizon seems to be taken up with green bushes. The dwellers on the llanos account for the increase of forest land by the diminution of the number of cattle during the last thirty years, one of the unfortunate results of the endless revolutions of this period.

The rainy season of the llanos lasts from April to October; in November only a few scattered showers fall, and are at once absorbed by the vertical rays of the sun. The consequent drying up of the ground occurs in the higher-lying districts (*Llanos altas*) earlier than in those which are situated near the rivers. Large tracts of land in the neighbourhood of Calabozo were found lying under water; while the *Llanos altas*, which during the rainy season furnish such admirable pasture-land, were entirely dried up.

Humboldt gives the following description of the llanos at this season:—"When, beneath the vertical rays of the never-clouded sun, the charred carpet of grass falls into dust, the hard ground gapes asunder as if cleft by a violent earthquake. The east wind, as it passes over the heated earth, brings new heat instead of coolness. Even the pools, sheltered from evaporation by the bleached leafage of the yellow fan palms, gradually disappear. As in the icy north the animals are benumbed by the cold, so in these burning plains the crocodile and the boa-constrictor sleep motionless, buried deep in the dry clay. Wrapped in dark clouds of dust, tormented by hunger and thirst, horses and oxen wander to and fro, some with low bellowing, others with outstretched necks, panting against the wind, and trying to scent, by the moisture of the atmospheric current, the vicinity of some tarn not yet wholly dry. Even when the burning heat of day is followed by the coolness of the night, which is here always of equal length, oxen and horses are not allowed to enjoy any rest. Bats of monstrous size light upon them during their sleep, and vampire-like suck their blood, or hang upon their backs, creating festering wounds, in which mosquitoes and other insects take up their abode; so that the tormented creatures lead a painful life when the water has disappeared from the earth, beneath the scorching heat of the sun.

But when, after long-continued drought, the beneficent rains fall at last, the steppe is suddenly transformed. The deep blue of the as yet unclouded sky becomes paler. From the horizon, like a distant mountain, rises vertically towards the south a solitary cloud. Like a gathering mist the vapours gradually spread over the sky. Distant thunders herald in the quickening rain. Scarcely is the earth wet, before the steppe is covered with kyllingia, panicled paspalum, and various grasses. Stirred by the light, herb-like mimosas unfold their drooping, slumbering leaves, and greet the rising sun, together with the matin song of birds and the opening blossoms of the water plants. Horses and oxen graze in the fullest enjoyment of life. The tall upspringing grass conceals the spotted jaguar. Lurking in some safe ambush, and carefully measuring the width of his single spring, he pounces upon the passing prey, like the Asiatic tiger.

Sometimes, so say the natives, the moistened clay on the borders of the swamp is seen to move slowly and in heaps. With a heavy thud, like the eruption of a miniature mud volcano, the loosened earth is hurled high into the air. Whoever sees the sight, flees far away, for it is caused by some gigantic water-snake or scaly crocodile, roused from his death-like stupor by the first fall of the rain. Gradually the rivers bordering the southern edge of the plain overflow; and nature, which in the first half of the year compelled the animals to pine and droop for thirst upon the dusty, barren soil, now forces them to live as amphibia. Portions of the steppes appear like a vast inland lake. The mares, with their foals, retreat to the higher banks, which rise like islands above the surface of the lake. The dry land grows smaller day by day. Crowded together, the hungry animals swim to and fro in search of food, and gain a scanty sustenance from the grasses which rise above the brown, troubled water. Many of the foals are drowned, some of them are seized and swallowed by crocodiles; and not unfrequently horses and oxen, which have escaped from the jaws of these greedy and bloodthirsty reptiles, bear upon their bodies the marks of the pointed teeth.

But the jaguar and the crocodile are not the only enemies which attack the South American horse. A dangerous foe awaits them among the fish of the steppes. The marshes near Bera and Rastro are filled with numerous electric eels (*Gymnotus electricus*), whose slippery, yellow-spotted bodies give

ELECTRICAL EEL (*Gymnotus electricus*). Length, 5 to 6 feet.

out from every part the electric shock at will. These fish are from four to six feet in length, and strong enough to kill the largest animal when they discharge their fatal battery with good effect. The track across the steppes was once obliged to be altered because eels had assembled in such numbers in a small stream that many horses were killed every year in fording the water. All other fish flee from the approach of this dreaded eel; and even the fisherman on the bank is terrified when the distant shock is conveyed to him through the moistened line in his hand.

Humboldt describes the capture of the electric eels as a picturesque spectacle. "Horses and mules are driven into the pond, which is closely guarded round by Indians. The unwonted noise rouses the fish, and the attack begins. Snake-like, they are seen winding through the water, and trying to swim beneath the horses, and deal their fatal shock. Many of the animals succumb to the invisible stroke; others, with bristling mane, snorting, and flashing eyes, dash from the dreaded place; but the Indians, armed with their long bamboos, drive them back. Gradually the unequal battle wages less fiercely. The wearied fish disperse like emptied thunder-clouds. They need long intervals of rest and a supply of nourishing food to replace the galvanic force they have expended. Fainter and fainter grow their shocks. Terrified by the trampling of the horses, they timidly approach the shore, where they are caught with the harpoons, and drawn on land with dry, non-conducting wood."

Sachs, whose mission it was to observe these fish in their native waters, and convey specimens to Europe, took it as a matter of course that he was bound to employ the method of capture described by Humboldt; but the high price demanded for the horses and mules, owing to the diminution of their numbers, made him hesitate. He therefore, on the first day of his stay in Rastro di Ariba summoned to his home a number of resolute fellows, and proposed to them to attempt to capture the eels by the aid of less expensive asses. At first they did not understand him; but when he told them of Humboldt's description, they broke out into such peals of laughter that he could scarcely bring them back to anything like serious attention. Neither they nor any one whom he questioned later had ever heard of such a mode of capture. It never could have been the custom to catch the eels in this way, or some trace of the practice must have remained in the memory of the people. Sachs thinks that the horses must have been driven in merely to startle the fish, and give the Indians a chance of harpooning them, and certainly not from any idea of exhausting their electric force. Such an attempt would be quite unnecessary, because the long dry cord to which the harpoon is fastened is a sufficient protection against the shock. However that may be, the whole process must have been an isolated experiment. There is no regular method of capturing the electric eels of the llanos; the fish are objects of terror and loathing to the inhabitants, who go out of their way as much as possible.

But other dangerous fish are harboured in these waters, the greedy *Pygocentrus Nattereri*, and the *Trygon hyotrix*. The latter is a flat, circular fish, with a thin, pointed tail, armed with a long spike ending in a hook, which it can erect at will, and which is a more formidable weapon than it appears; for the fish, buried in the sand, and almost hidden from view, darts it with sure aim at the unwary traveller, and the wound inflicted is venomous to a degree difficult to be accounted for.

We will mention the well-known lantern-fly (*Fulgora laternaria*) of Surinam, merely to observe that scientific men have always disputed, and dispute still, as to whether it really can give out light. On the other hand, Schomburg relates that at the mouth of the Orinoco, when the twilight closes in, the air is illuminated in every direction by thousands of shining insects. He describes also, in connection with the higher animal life, which is not perceptibly different from that of the Amazon, the torments inflicted upon him by the sand flea (*Pulex clavata*), and by small ants, mosquitoes, and a large ant (*Ponera clavata*). The sting of the latter not only rendered him unconscious, but confined him to his bed for a whole day, by the fever arising from the wound. He describes also the rattlesnakes in the savannahs of Guiana; and lastly, the large number of hideous lizards, toads, geckoes, scolopenders, and scorpions. Among the lizards, the tree liguan (*Iguana tuberculata*) is the most repulsive in appearance; its flesh, however, is said to be the tenderest that can be procured. One of the most curious birds is the crag-dancer (*Rupicola crocea*), found in the mountain valleys and forests. It is an oddly shaped bird with beautiful plumage, and dances to attract the hen bird.

The llanos are also the home of the wild cattle, or *Ganado vacuno*. The breed resembles the Dutch cattle; the cows yield but little milk, but are strong, and easily fattened, especially when fed with salt. This favourite dainty is given to them to tame them, and prevent their running away. We

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have already mentioned the insectivorous birds (*Crotophaga ani* and others), which live on intimate terms of friendship with these cattle. But to shew how little has as yet been done in the development of cattle-rearing, it will be enough to mention that in the whole territory of San Martin, on an area of about 100,000 square miles, only about 120,000 head of cattle are kept, while, according to the opinion of the settlers, there is room for five millions.

The spectacle of a great fire on these plains is thus described by Sachs: "We had soon lost sight of the towers of the city of Calabozo, and were enveloped in dense clouds of smoke blown towards us by the trade-winds. A large tract of the horizon was lighted up by the flames, which, seen through the watery vapours of the atmosphere, gleamed with a blood-red, lurid glare. As soon as the drought is sufficiently severe, the parched pasture lands are set on fire in order to improve the grass crops of the coming year by manure. Many records of travels contain sensational descriptions of the dangers attending these prairie fires, from which the traveller could scarcely hope to make good his escape. I have convinced myself, more than once, that even with a favourable wind and perfectly dry grass of several feet in height, the flames do not spread quickly enough to overtake a pedestrian, far less a man on horseback, and that real danger is scarcely possible unless one were so incredibly careless as to enter a tract of land entirely enclosed by the flames. We were frequently compelled to pass so close to the fired grass, that our horses shewed symptoms of shying. One of the most interesting sights attending the prairie fires is the number of birds of prey which hover high in the air over the outskirts of the advancing fire, and swoop down from time to time with lightning speed upon the lizards, snakes, or other little creatures fleeing from the flames."

The attempts at colonization made by the intelligent inhabitants of the llanos, in localities of their own selection, are all without exception successful, and shew that besides the "frutas menores," or articles of every-day consumption, products such as coffee, sugar-cane, and cocoa can be obtained of the best quality, without, however, altering the fact that both in the present and for the future, the chief importance of the llanos will be found in cattle-breeding. The time at which the llanos will be thrown open to agriculture cannot, however, be very near at hand. Wide valleys and extensive highlands in the mountain districts are even yet entirely untouched, and covered with virgin forests; and if civilization has not taken root here, although centuries have passed away since the immigration of the white races, how much less chance is there for the llanos, whose burning climate contrasts so unfavourably with the eternal spring of the *tierra tremblada*, or temperate region, between 1,200 and 6,000 feet above the sea.

In Guiana the primeval forest follows the course of the rivers, which are generally covered with Victoria Regia. It has been observed, especially with reference to the Rio Essequibo, that the vegetation depends very much upon the amount of light received. The high woods are composed of trees growing in close ranks, and joined together by the tough network of the llanos, while parasites twine alike round the living and the dead trunks. Above the dense roof of leaves and branches towers the mora (*Dimorphandra excelsa*), a tree bearing leguminous fruits, and growing to the height of 150 feet. It is a picture of wild, luxuriant life; but the eye misses the bright flower carpet spread on the sward in other climates, and has to content itself with mushrooms, ferns, and decaying vegetable matter; for even at mid-day the light is dim and faint, and scarcely a strip of sky is visible through the entangled branches overhead. But along the river banks, on the outskirts of the forest, the vegetation assumes a different character. Here, in the more open tracts, and on the moister soil, the undergrowth prevails over the larger trees. A belt of bamboos and broad-leaved nettle-worts (*Cecropia*) rises in the foreground, pliant lianas weave above tree and bush, round which grow their luxuriant enclosure, flowering arum and aromatic spices, and the favourite cayenne pepper plant (*Capsicum annuum*), now so frequently cultivated in all its varieties in most warm countries, and even in the south of Europe. But wherever the rivers are unable to penetrate, nothing is found but llanos, and even a great part of the mountain is barren, or covered with meadows of grass mixed with a number of low shrubs. The sea-coast is fringed with tracts of land given over to agriculture, with respect to which there is little now to be said. We find there the cabbage palm (*Euterpe oleracea*), the West Indian cabbage palm (*Oreodoxa oleracea*), the royal palm (*Oreodoxa regia*), and, as objects of culture, the oil and cocoa palms. These comparatively speaking new formations of the coast land are continually increasing under the influence of the mangrove woods, which are situated close to the water's edge. Besides their usual component parts, the mangrove woods of Guiana contain the mango tree (*Rhizophora*), anicenniæ, combretaceæ, and figs. All these plants, by the formation of their aerial roots, seize hold of the soil as firmly as so many anchors, and are often able here, as in Panama, to keep their hold through the attacks of a raging tide.

"On landing," says Humboldt, "a sweet, sickly smell came towards us for about ninety to a hundred and twenty feet, similar to that given out by the mouldering wood-work in the shaft of an abandoned mine when the candles are beginning to burn low. Gentle as is the ebb and flow of the tide, it is sufficient to leave the roots and a part of the stems of the plants alternately dry and submerged beneath the waves. When, then, the hot sun falls on the moist wood and slimy ground, heating the fallen leaves and the crustaceæ clinging to the seaweed, chemical gases are probably formed, which defy analysis. The sea-water assumes a brownish-yellow hue along the whole coast wherever it comes into contact with the mango tree; and wherever the latter grow upon the sea-shore, numberless molluscs, especially mussels, snails, and shell-fish, appear upon the strand. These creatures love the shade and twilight, and in the dense tangle of the roots, which stand like a network over the water, find a protection against the beat of the waves. Shell-fish cling to the trellis-work, the crabs creep within the hollow stems, while the weed and seagrass, driven ashore by wind and wave, hang from the drooping branches. In this way the mud gradually accumulating among the trees increases the dry land. But while the forests gain upon the bed of the sea, they scarcely increase at all in width; for the mango trees, and the other plants which always accompany them, die as soon as the soil becomes dry, and the roots are no longer standing in salt water. Their ancient trunks, half covered with crustaceæ, half buried in the sand, shew after centuries the way they have wandered, and the boundaries of the territory they have wrested from the sea."

We close our description of this region with the following picture of a scene in Ecuador, as depicted by Kolberg. Colon is reached by the traveller. "Great Columbus," he exclaims, "in life thou didst experience the bitterest ingratitude from thy fellow-men, and even after death thy name is disgraced by having been given to this most hideous place of abode. Trackless swamps surround the wretched marshy hole, and an intolerable stench is wafted towards us from their waters. Away to the shores of the Pacific, for Panama. First of all the train carries us through wide marsh lands, overgrown with all sorts of bush and tropical kinds of cane and sedge, and then through the high woods which extend to Panama. At times we skirt the shores of a tolerably wide river, which rolls its turbid yellow waves towards the Caribbean Sea. The water is fringed with calladiæ and bananas with leaves three feet wide and twelve feet long; slender bamboos shoot up to the height of forty-five feet; among them the *Carludovica palmata*, a pandanus akin to the form of the dwarf palms, and called, on that account, the banana palm, which is useful in providing the costly material for the Panama hats. And these plants are but the low sedgy growth of the shore, above which rise the colossal trees of the primeval forest, and the fruit-laden branches of the various kinds of palm. Every tree is a garden in itself, draped with hundreds of climbing plants and parasites, and the variety of all this splendour is infinite, the scene changing at every instant. The finest conservatories in the world are dwarfed into insignificance by this majestic flora, which exceeds all that the most vivid imagination of the botanist can paint. I have read the brilliant descriptions of tropical scenery written by Humboldt and other travellers, but, in my opinion, no writer or painter has, as yet, described even approximately the virgin forests of the tropics. The scene is animated by an incredible number of birds, large and small, and of the most brilliant colours, especially marsh birds: quadrupeds are scarcer, but still many may be observed climbing about the branches of the trees; in the marshes creep and glide reptiles of the crocodile species, and one or two large snakes writhe alongside the train as it passes by.

First Waterfall of the Rio Caroni, near its Source in the Boramia Mountains, on the Borders of Venezuela and British Guiana.

"From time immemorial the virgin forest has been the paradise of the botanist and zoologist, and yet the first impression which it makes upon the traveller is often rather depressing than exhilarating. Where is man, the lord of all creation, who should control this unrestrained nature? Alas! he is not there to assert himself, he has shrunk back powerless, and left the sovereignty of these forest depths to their real sovereigns, the crocodile and the jaguar. The fabulous wealth of the tropic lands is, to their human denizens, a treasure hidden behind bolt and bar, far away out of their reach. If he extirpates to-day a hundred plants to prepare the ground for his use, he finds a thousand weeds growing wild in their place on the morrow. And the traveller experiences a strange and painful sensation on seeing so few trees come to their full growth. The immeasurable growth of the underwood stifles the higher vegetation in its germ, and the parasites climbing to the very crest of the highest trees, rob them of light, and bring them to decay long before they have reached their prime. Hundreds of plants of every kind, from the tiny grass to the gigantic palm tree, spring up from every niche of this fertile soil, and, closing in a tangled embrace, struggle one against the other for life and light; and if the majestic tree is dragged down by the picturesque lianas which have climbed high up its crest, and woven an impenetrable roof above its topmost bough, it sends up another shoot stronger than itself, and begins the life-struggle all over again. The beauty of such a scene has nothing European about it; it is too wild and grand; but it has a beauty of its own, a beauty like the strife of the wild bull with the bloodthirsty jaguar. As relentless as the combat of plant with plant, so deadly—nay, more deadly—is the unceasing war between the different wild creatures of the forest. For them, in this Eden-like garden, the peace of Eden never comes. They lurk apart, each watching and shunning the other, seeing enemies everywhere. But we must not imagine that more wild animals shewed themselves than would be found under similar circumstances in Europe; that is to say, in the districts adjoining thoroughfares frequented by men. Apart from certain privileged spots, almost the very opposite is true, though, perhaps, some birds strike the European more strongly by their strange form and vivid colours. It is different in the depths of the great woods which are hardly ever penetrated by men; and another exception is formed by certain aquatic animals, such as sharks in the sea and crocodiles in the rivers."

The Rio Magdalena carries us past the Cordilleras into the interior of the country, where we become acquainted with the Guayas (Guayaquil). When the great rains set in, this river overflows large tracts, and, like the Nile in Egypt, brings down with it from the forests a fine and highly fertilising slime, and so manures, year by year, the already fruitful soil. But, unfortunately, this rich soil is by no means of the use which one would naturally expect. Without any exaggeration, we may say that it is capable of supporting at least a hundred, perhaps a thousandfold, more people than it does at present. Luxuriant meadows often extend to great distances along the shore, but they present a wild and neglected appearance. Thousands of cattle roam over them, but not nearly so many as they could provide with pasture, and among a hundred cows hardly one is ever milked, except when they are temporarily detained near some ruined hacienda. But wherever man takes the trouble to till the land by his own industry there extends by the river-side a constant alternation of dense plantations of sugar-cane, rice, indigo, and tobacco; with luxuriant cacao woods and coffee plantations, interrupted by pineapples and bananas. These plantations thrive in such luxuriance that they rise one above another as it were in three or four storeys from the same field. In several parts of Europe we may be familiar with the sight of vegetables or grass growing under fruit trees, but the different kinds react for evil one upon the other;

the trees depriving the plants of light and sunshine, and the plants seizing the lion's share of the fertilising substances lying near the surface of the earth; while hardly anything will thrive, or even live, under very shady trees. Here, however, on the fertile banks of the Guayas, above the stems of the coffee plant, which reach the height of six or nine feet, rises the tall banana, twenty-four or thirty feet high, loaded with fruit, and closely planted like a wall; higher still towers the great mango tree, spreading out its leafy, circular crown, which droops down again almost to the ground. Between the mangos stand cocoa palms, their slender stems triumphing over their more unwieldy neighbours, and their crown of feathery leaves waving high overhead in the blue ethereal air. The inexhaustible soil would yield more, if that were permitted, and the agriculturist has to do battle against the intruding parasites and lianas, which would damage his crops. Among this verdure, which is only possible where the river carries on its yearly work of fertilisation, and where the intense sunlight pierces through every rift and crevice in the uppermost roof of leaves, and sends to the soil its arrowy shafts of light, tempered, it is true, but still bright enough to bring sufficient light for the plant life—among this verdure lie hidden the picturesque huts of the natives, generally built upon a foundation of high piles, as are also the charming and more imposing haciendas of the Spanish señores.

The Tropical Andes of South America.—The Andes of New Grenada, Ecuador, Peru, and Bolivia.

Of all the narrow coast lands to the west of the Andes, which are washed by the Pacific Ocean, Peru alone belongs to the region of the tropical Andes. Its eastern boundary is vaguely defined, but it never encroaches upon the vast plains. The actual frontier line is considered by botanists to be traced by the lower limits of the cinchona forests. In this part of the Andes, which extends from 9° N. lat. to the southern tropics, we are able to distinguish almost everywhere two great mountain chains called indifferently Cordillera de los Andes, although, strictly speaking, the eastern chain alone is entitled to the name. Between them lies a more or less extensive plateau. On the southern tropical circle, where Bolivia comes in contact with the coast, the high peaks and crests of the Cordilleras disappear almost entirely for a time, and the desert of Atacama forms a highland plain, extending from the ocean to the Pampas, and forming the natural boundary between the flora of Chili and that of the tropical Andes. In Peru the region has five districts, sharply distinguished one from the other by climate, flora, and partly also by their fauna; in the remaining parts the lowest or coast district is not found.

The coast region extends from the sea-shore up the lower slopes of the Cordilleras, to the height of about 4,500 feet; it is characterised by its want of rain and the so-called *garuas*, or exceedingly fine mists, which occur from May to September, without, however, moistening the ground to any perceptible extent. Thunder and lightning are almost unknown, and when, on the 31st of December, 1877, flashes of lightning and two claps of thunder were seen and heard at Lima, the people were thrown into the utmost consternation, more, indeed, than by the burst of rain which followed, and lasted for a quarter of an hour, although no rain had fallen in Lima since the year 1803. The climate of the coast region is generally temperate. Lima, for instance, although it is situated below 12° 2′ S. lat., has an average yearly temperature of only 68° Fahr.; and its climate is therefore totally unlike the burning climate of the adjoining country of Ecuador, where the coast belongs to an entirely different vegetal region; namely, that of cis-equatorial America.

The name Sierra, or mountain range, is given to a region extending from 4,500 to 10,500 feet above the sea level, both in the western districts of the coast mountains, and also between the two Cordilleras. In this region it rains from September to April. The want and excess of rain therefore characterise the region of the coast and of the mountain slopes, and the construction of the houses differs according to their position in one or the other district. On the coast the roofs are flat, while on the mountain-side a sloping roof is indispensable to allow the rain-water to run off; so that even an inexperienced traveller is able to decide at a glance in which of the two regions he is wandering, whether on the coast or in the Sierra. The climate of the latter district is temperate, the thermometer seldom rising to 72°, and as seldom falling to the freezing point.

The higher region, Puna, is chiefly formed by the highland plateaus lying between the crests of the Cordilleras; it extends up to 12,000, or even 13,000, feet above the sea level. The temperature is low, the thermometer falling sometimes during the night to fourteen degrees Fahrenheit.

Nevertheless the region is not unfruitful, and may be regarded as the district of pasture lands. These pasture grounds of the Puna correspond to the Paramos of Ecuador, and the Pajonals of Columbia.

The fourth region, or Cordilleras, is formed by the mountain peaks which rise above the Puna; and is, if not throughout the whole year, yet certainly for the greater part of it, covered with snow, and exhibits nothing but a meagre crop of very short grass in the few patches of land where the snow does not lie.

The name of the fifth region, Montana, does not, as its name suggests, indicate a mountain region. It is exclusively used to designate the eastern slopes of the eastern Cordilleras, which are covered with primeval forests. Abundance of rain falls here, and owing to the extraordinary wealth of vegetation the air is generally very moist.

This brief survey of the climatic peculiarities of this region must suffice us, as it does not lie within our limits to explain more in detail how the Humboldt River, flowing from the south, and washing the coast of Peru, condenses the aqueous vapours and dries the atmosphere, because it is colder than the land by which it flows; or how the comparatively dry winds, by blowing parallel to the Andes, diminish still more the possibility of abundant cloud formation.

With all these widely differing climates, it is no wonder that the plant world of this region is richly represented; but it is so only in a certain sense. Products of every zone, from the torrid to the frigid, are found; but the representative plants of each individual zone exhibit comparatively few specimens; and the region, as a whole, cannot for an instant be compared with the vegetation of the East Indies, for example, with reference to the number of species represented. But if a gentleman from the far north, that is a landed proprietor, plagued in his mountain hacienda by the climate of St. Petersburg, desires to enjoy the air of Paris in the month of May, he has but to journey southward for an hour or two to Quito, 9,000 feet above the sea; should he prefer the climate of Venice, he can go still farther down, and stay at Puembo, which is rather more than 7,500 feet from the plain; but if he needs a Sicilian air, another ride of a few hours will bring him to Perucho, 5,700 feet high. At home, for his first breakfast our traveller can obtain nothing but milk and potatoes; for his *almuerzo*, or second breakfast, at Quito, all the finest European vegetables to be procured in Paris are at his disposal; his luncheon in Puembo will include every kind of Italian fruit, and in the evening his host at Perucho will entertain him right royally with tropical fruits not to be found in Sicily, and all this without the aid of the steam engine.

The coast district is composed chiefly of a wide sandy plain, broken by fertile valleys here and there. The sandy tract resembles the deserts of other countries. But when we speak of this part of the coast region as a desert, we must remember that during the garuas it is covered with green turf and no inconsiderable number of flowering shrubs. Where, during the summer, nothing is seen but a barren solitude, the germs and buds are lying hidden within the ground, and only in the higher-lying regions of Atacama, above the region of the garuas, and consequently deprived of even the fine summer rains, do we find wide stretches of rocky ground entirely without vegetation. As in the deserts of Africa, so also in the regions of the coasts and of the Atacama, the tree-growth is not altogether excluded, but the trees grow at wide intervals, and are of moderate height; most of them are evergreen, belonging to the olive (*Budleja*), tamarind, and mimosa (*Prosopis*) forms. But although during the summer the coast districts of Peru and the mountain slopes resemble an almost treeless waste, the eye is nowhere deprived of the sight of refreshing verdure; numberless cacti (*Cereus Peruvianus*) and agaves always keep their colour and vital force. Second to them in the capacity of resistance, either permanent or at least temporary, to the season of drought, rank the hairy shrubs and the liliaceous plants, whose subterranean organs are preserved in all their freshness underground.

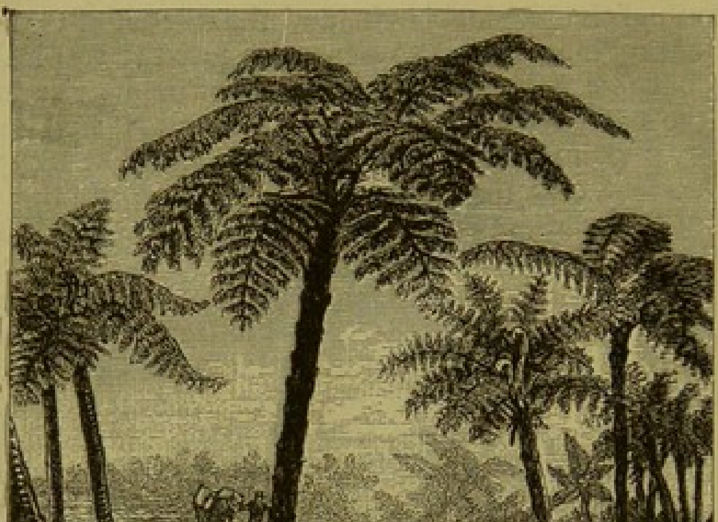
Wherever a river, hurrying seaward through the coast region, moistens its banks with the life-giving element, man has, by cultivation, thrust back the original vegetation, and by the aid of artificial irrigation has endeavoured to enlarge such tracts. The canal of Uchusuma, for instance, carries down the water from the mountains to Tacna; another canal is found at Payta, and various small mountain lakes in the Cordilleras have been dammed up to increase the volume of the Rimac, which waters the valley of Lima. In the fields thus obtained every kind of tropical plant grows in the richest profusion and variety. Side by side with the principal agricultural products which supply the chief food of the people, as rice, maize, manioc, batata, and potatoes, and clover for fodder for the domestic animals, we find sugar-cane, vine, olive, banana, and cotton, together with opuntias to feed the cochineal insect. The sugar-cane is by far the most widely cultivated of all these plants, and especially within the last few years, when its production has increased to such a degree as to warrant the hope that when the wounds of the last war are healed, sugar may become one of the chief articles of export of Peru. The culture of the vine is also important, especially in the departments of Ica, Arequipa, and Mocquegua, which produce excellent wines, and the famous Ilatin brandy. To complete the list of objects of culture, we must add that in the Sierra the various European cereals are also grown, and yield good crops. But the characteristic plant of the region is maize, which is probably indigenous here, since its grains are already found in the graves of the ancient Peruvians. Next to maize, the principal objects of culture are wheat, barley, potatoes, clover, peach, and apple; together with the oil-sunflower (*Helianthus annusis*), which is a native of Mexico and of Peru. In the higher regions grows a kind of orache (*Chenopodium quinoa*), from whose numberless small seeds is made a sort of bread, sweet-tasted, and owing to the amount of starch which it contains, extremely nutritious. The leaves of this plant are eaten like our spinach, as a vegetable. Besides the quinoa, we find a kind of potato, from whose tubers, when dried and exposed to the frost, the so-called *chuna* is obtained. In the lower districts of the Puna, potatoes and barley are grown, but the chief wealth of the place consists in its large pasture grounds, on which various kinds of grass flourish. The Cordillera, wherever it is not covered with snow, is overspread with a carpet of verdure only a few inches high, able to offer but a meagre sustenance to the vicunas and alpacas

BALSAM OF PERU (*Myroxylon Peruvianum*) AND SARSAPARILLA (*Smilax sarsaparilla*).

which inhabit the highest peaks and chains. The Montana possesses a very luxuriant vegetation. Besides the tropical plants mentioned above, it produces coffee, tobacco, and cocoa, together with a large number of medicinal plants, spices, and useful woods. Among its special productions are China bark, sarsaparilla, vanilla, copaiva, balsam of Peru (*Myroxylon Peruvianum*), numerous kinds of gum, caoutchouc, and several little-known kinds of woods, both for timber and ornamental purposes ; cedar wood, yacaranda, lumballo, palocruz, la caoba, and others.

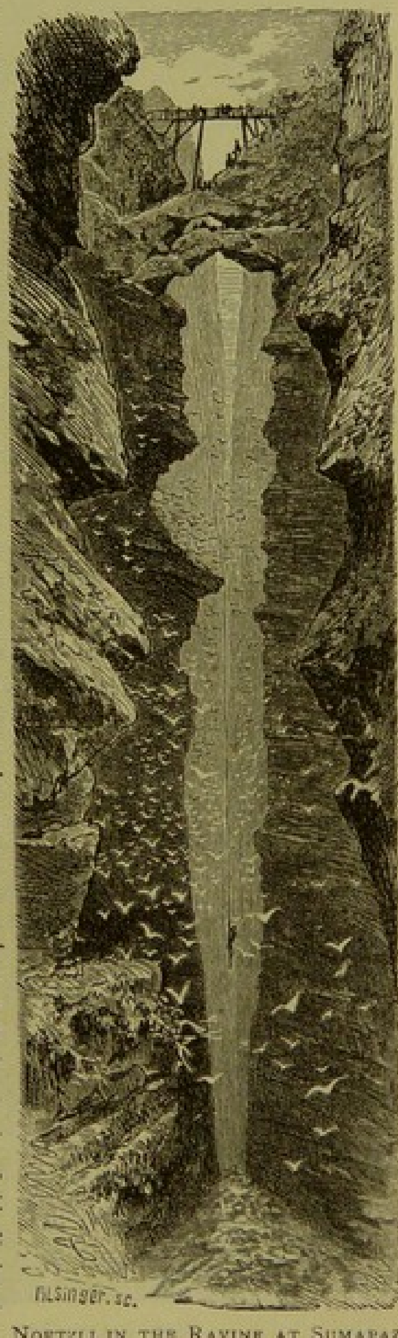
The palms are exceedingly worthy of note ; a splendid palm vegetation extends along the coast from Ecuador and Peru, until it comes to a meagre end to the south of the tropical region of the Andes, in Chili, including the island of Juan Fernandez, with the *Jubeæ spectabilis*, or Chilian sugar-palm, and a wax palm (*Ceroxylon Australe*). The former, a palm from thirty to thirty-seven feet high, with feathery leaves about six to nine feet long, is found growing wild on the heights of Aconcagua. To the south of Valparaiso, as far as Valdivia, where it no longer yields ripe fruits, it is probably only a cultivated plant run wild. Numerous palms are found in the moist valleys of the Andes, both in Bolivia and the Cordilleras of Cochabamba; they only diminish in numbers to the south of the tropical circle, and the district of Gran Chaco, situated to the west of our region, appears to penetrate into the tropical zone as a territory possessing but few palms. Several kinds of palms rise in the Andes (quite contrary to the ordinary nature of the tree) to great heights above the sea level; thus the wax palm (*Ceroxylon andicola*) is found at 8,475 feet, *Guilelmia speciosa* at 4,200 feet, and the *Oreodoxa frigida* to 8,400 feet; but all of these are surpassed in this respect by the *Euterpe andicola*, which is found in Bolivia 9,000 feet above the sea level.

In treating of the flora of Columbia, we accepted André as our guide, who brought us as far as Bogota. We follow him on his journey down the Rio Magdalena to Ibague, and over the Cordillera of Quindiu to Carthago and Cali. The descent was attended with many obstacles. A track made of tree trunks—a steep descent transformed by the Indians into a practicable thoroughfare, by laying across it trunks of the tree-fern—was especially difficult. The trunks lay like great shafts of a column, black, wrinkled, hairy, marked by the scars of the fallen leaves. The terrible path extended over several miles, and then led into a forest of magnificent tree-ferns, the sight of which made all previous fatigues forgotten. Towering aloft into the blue vaporous air, numbers of these incomparably beautiful plants were clustered together. They were actual trees of thirty to forty-five feet high, with feathery crowns that gave them something of the appearance of palm trees. André counted twelve different varieties, and did not think that he had exhausted the number of those before him. After travelling for some hours in this enchanted forest, a change in the vegetation was observed, increased brilliance and diversity of form revealed the approach of the *terra caliente*, and the ferns began to disappear in the shadow of the undergrowth. Before long Fusagasuga was reached. Not far from this spot is the famous bridge of Icononzo, so admirably described by Humboldt, and studied so accurately by Gros. Looking down from its hand-rail, the gaze falls down a black abyss with perpendicular walls, where, like a white ribbon 300 feet below, the Rio Sumapaz foams along its rapid course. When the eye becomes accustomed to the semi-obscurity, it sees from time to time swarms of birds darting like arrows to and fro above the waters, and the ear catches their shrill cries. The bird is the guacharo of the Venezuelans, the guapaco of the natives (*Steatornis caripensis*), a member of the family of night swallows, twenty-two inches long and with outspread wings more than three feet wide. Its home is built in the rocky sides of the abyss. Noetzli, a companion of André, laden with a sack, a gun, a hammer, and a knife, was let down from the bridge, suspended by four leathern straps, in the sight of a large concourse of people. The straps were held by ten powerful men. Ninety feet below was a grotto, in which the birds, for whose sake he descended, built their nests; indeed, all the walls were closely covered with nests. Thirty feet lower still was a projecting ledge of slate and a second cavern. In spite of the shrieks of the birds, both caves were inspected, and one guacharo was caught alive, together with a nest and three eggs. After this success Noetzli was let down a second time, but this time circumstances occurred which placed him in no small degree of peril. The ledge of slate had a projection by which he was hidden from the view of his friends, and could not be seen from above, and in this place he was so fiercely attacked by thousands of guacharos, that he was forced to draw his knife in self-defence. He cried out to his comrades to draw him up, but his voice was lost in the roar of the torrent and the shouts of the multitude, and he found himself continually lowered toward the water. It was not until he had almost reached the foaming flood that the danger of his position was perceived, and he was drawn up amid the applause of the crowd. A long document written by the Alcalde of Pandi attests this "first attempt of its kind" in pompous phraseology; although Gros had made the descent several years before. The guacharo is the same bird which Humboldt discovered in the cavern of Caripe.



Road made out of Tree-Ferns, near Quindiu.

The rest of his journey led André across the Cerro di Viotá. There, at 5,300 feet above the sea level, he encountered the first oak forest, not like a forest of central Europe, nor even such a one as is found in the Mediterranean region; but composed of giant trees with wrinkled, dun-coloured, upright trunks, bearing aloft a splendid roof of leaves of the laurel or magnolia form. The ground was bestrewn with leaves and acorns larger than walnuts. The whole wood was composed of these trees (*Quercus Humboldtii*), and contained no other shrub or plant, except a curious orchid (*Catasetum*) and a fibrous fern (*Acrostichum*). Seldom did a ray of light penetrate the dark mass of leaves, and a solemn and unbroken silence reigned in the enchanted forest. Near Guataqui, the Rio Magdalena, there only 1,200 feet wide, was crossed. The river valley, here perfectly barren and desolate, extends far away to the foot of the central Cordillera. Only here and there do fleshy plants, opuntias, leadworts, and similar growths, relieve the dull monotony of the plain, and only where the brooks had dug for themselves a deep channel did a few green clusters show the presence of the life-giving element. It was in this place that in the year 1595, on the 12th of May, the Mesa de Herveo had poured forth its devastating torrent of mud thirty to ninety feet deep. A number of birds rewarded the skill of the sportsman in these solitudes. An exquisite little creature with ruby feathers (*Pyrrhocephalus rubineus*) was trustful even to rashness. By a pool of water, upon which are seen beautiful water plants and a small blue and white pontederacea, rose a singular bird, which the mule-driver called "clo-qui," a name given to it in imitation of its peculiar cry. It is of the same size as a goose, with red and white plumage and crooked bill, and may probably be an ibis. Another bird, a plover (*Vanellus Cayennensis*), larger than our European plovers, is also found. Nothing of particular interest is narrated of the march across the Quindiu, except the description of the wax-palms (*Ceroxylon andicola*), which, says André, "appear at last in all their majesty, their roots in the water, their crests in the clouds. Their stems, seen from afar, look as white as ivory, and bear aloft a sheaf of splendid leaves, often more than eighteen feet long. But the forests are becoming clearer day by day; for the beautiful old trees which have stood there for centuries are cut down by thousands. When they are felled, the stem is scraped, and the wax which has exuded through the bark, and formed a layer 0·2 of an inch thick, is packed in sacks, and sent to Bogota, where it is made up into matches." Sometimes, though more rarely, the wax is obtained by a workman who climbs up the stem by means of a strap fastened to his body and to the tree itself, and who, as he descends, scrapes off the wax. Every tree furnishes from sixteen to twenty pounds of white or yellow wax, which is worth about one shilling a pound. The trees, from 180 to 240 feet high, are found as far as the limits of the Paramos, at a height of 5,700 to 9,000 feet above the sea level. On the eastern slope of the pass of Quindiu (10,450 feet), André went into a hacienda, where all the woodwork was composed of the stems of the wax-palms, while their giant leaves, silver white on the under-side, formed a warm, impenetrable roof. The building was quaintly and characteristically adorned with the skins of jaguars, bears, pumas and other wild beasts which frequent these solitudes. The sight of them was an incentive to the chase, and a jaguar was seen, but nothing captured. To make up for this failure, a wax-palm was felled: its fruit cluster, six feet in length, bore numbers of orange-coloured fruit, with sweet pulp, and about the size of a large grape. Lupines, a kind of fragrant whitethorn, large tree-like groundsel, sumach, barberries, and even strawberries, which are not uncommon in Columbia, remind the traveller of European forms. Higher up, the plants become scarcer, more stunted, and bent by the wind, the road grew more difficult, and the mules were plagued with horse-flies. In the descent, at 8,000



NOETZLI IN THE RAVINE AT SUMAPAZ.

feet above the sea, giant oaks were met with, and a new wax-palm (*Ceroxylon ferrugineum*), which at 4,800 to 5,400 feet was replaced by two other new palms (*Syagrus sanchona* and an *Astrocaryum*).

From 4,800 feet the path led through bamboo forests, which covered the country for miles without a break. The slender branches, covered with the tenderest green, met overhead in lofty arcades, beneath which reigned a profound gloom. The first clearing was planted with sugar-cane, and before long the travellers were greeted by the cries of a band of howling monkeys. The torrid zone was again reached. From there to the Rio de la Vieja the principal plant was a tree like wolf's-milk, which frequently grew to the height of seventy-five feet, and attracted attention by the ashen colour of its leaves. At the ferry leading to Piedra de Moler, the ferryman was waiting for them under the shadow of the pitcher plants, over which a beautiful orchid (*Jonopsis pulchella*) grew wild, and which had already been observed in the same place by Humboldt and Bonpland. After this the way lay across another chain of hills clothed in luxuriant vegetation; where one of the chief objects of attraction was the beautiful red flowering coral tree (*Erythrina corallodendron*), and from this point the first view was obtained of the wide valley of the Cauca, an emerald plain covered with pasture-grounds, fields, and woods, which stood out in fine relief against the violet tones of the western Cordilleras. The brick roofs of Carthago were clearly seen, where tall silk-cotton trees (*Bombax ceiba*) fringed the banks of the river. An admirable description of the Paramos is given by Kolberg. Painfully climbing the mountain range, through the region of forest and bush, where as we ascend higher we work our way through the myrtle-like growths and

WAX PALM (*Ceroxylon Andicola*).

eskallonias, we enter at last the Paramo, or, if we may so call it, the alpine meadow land. But let no one picture to himself the sunny fields and pastures which in Europe enchant the wanderer's eyes, by their fresh green and the glory of their flowers. Instead of the smooth turf, composed of short grasses and sweet mountain herbs, over which the foot treads lightly and with ease, we find ourselves up to the waist, and often indeed up to the shoulder, in the tall bunch grass (*Anthropogon*, *Stipa*, etc.), which, like certain reeds and rushes round the brink of a pool, forms high mounds and cushions of verdure. The ground is everywhere covered with dead grass stems, and after one of the earthquakes which are so common here, and cleave the ground into a thousand rifts and fissures, it is a dangerous task to cross the Paramo, something like the journey across a glacier covered with freshly fallen snow. For the natives, the very word Paramo is synonymous with every kind of misery and tribulation. There is, indeed, scarcely anything in the world more desolate than life upon these grassy plains constantly lashed by storms. At one moment the traveller droops beneath the almost vertical rays of the burning sun of the tropics, at another he is wrapped in a cold, moist fog, or seeking vainly for shelter from the storms of rain and hail which always occur two or three times in a day.

Nowhere does the inner formation of the rock reveal itself to the geologist. The first glance at the monotonous yellowish green and grey of the grassy cover fills the botanist with despair, and he is inclined to curse the fate which has led him from the luxuriant forest vegetation to this unpromising scene. But after all he is the best off, if he will only not lose heart as he crawls among the tall tufts of grass. Many a plant will he discover, bending down its drooping head to the warm ground; many a rare species of some familiar European tribe will surprise him, although, taken as a whole, the flora will bear no comparison with that of the Alpine meadows. Gentian, saxifrage, and a cabbage are found, but the vegetation becomes richer towards the snow-line, and the grasses retreat before some rare and curious plant forms. Ghost-like, draped in their mantles of grey felt, stand the spectral frailejones, *i.e.*, monks (*Culicium*), and the grotesque Gonda plant (*Lupinus nubigenus*). Everything is woolly, hairy, downy, and protected against the snowstorms; here, too, the Wernerias, and a few umbelliferous plants, scarcely an inch high, form a thick, soft cushion like moss, which is also found in several varieties.

The zoologist, also, will do well not to expect too much from an excursion in these districts. He may wander for weeks without seeing any of the larger quadrupeds; the Paramo stag, the larger felines, the bear, fox, and even the little Paramo hare, are too seldom encountered to give any animation to the scene, and smaller mammals, thanks to the great height of the grass, cannot even be seen. A few lazy vultures, and one or two small, sober-coloured, solitary birds (*solitarios*) rather deepen than relieve the profound impression of gloom and desolation. Through the evening dusk flits the zumbador, a bird resembling the snipe, but making a loud whirring sound with its wings as it flies. There are no amphibia in these high regions (10,500 to 13,500 feet high), except a hideous little toad, which announces and accompanies every shower of rain and hail with its harsh croakings. The only fish found in the brooks and standing pools is the small scaly sheat-fish (*Pimelodus cyclopum*), which is characteristic of the high Andes. A few butterflies and a number of little moths replace the rich butterfly fauna of the lowlands. The other insect classes are proportionately feebly represented. Nearer to the snow-line the fauna, or at least some classes, increase in number. Among others, the ptarmigan and a few exquisite humming-birds (*Oreotrochilus*), with snow-white, sky-blue, and emerald plumage, are seen hovering round the healing plant *Chuquiraga insignis.*

The most characteristic inhabitants of the high plateaus are the lama and the condor. The lama (*Auchenia lama*) is chiefly found in the Peruvian table-lands. Until the *Conquista*, or conquest by the Spaniards, it was the only domestic animal of the natives, and even now it is the trusty beast of burden for the travellers crossing the Cordilleras. Nothing is more beautiful than to see a long train of these black, brown, red, white, or speckled animals, with their thick fleecy wool, advancing in single file, each carrying a load weighing about a hundredweight, headed by the leader, who in former times was distinguished by a beautifully adorned halter, or by a little bell or banneret upon his head. They travel in this fashion up the snowy peaks of the Cordilleras, along tracks where even a mule could scarcely follow them. At the same time they are so docile that their drivers need no whip to guide them; but, on the other hand, they are subject to sudden panics, looking round on all sides with timid curiosity, and at sight of an unfamiliar object which rouses their terror they disperse in a moment in every direction, and the unfortunate drivers have much trouble in getting them together again. In the presence of strangers also they are prone to other discourteous habits. They will allow the real or supposed enemy to approach them within a few paces, and then laying back their ears, and putting on a very evil expression of countenance, suddenly spit their half-chewed balls of food into his face. It is to be regretted that the ass is generally replacing the lama as a beast of burden, for the latter yields milk, flesh, and a very serviceable wool.

A more elegant animal than the lama is the vicuna (*Auchenia vicunna*), an extremely shy and swift creature, with short wavy hair of extraordinary fineness. The Indians seldom make use of the gun to capture the vicuna. They assemble for the chase, and each family of the plateau is bound to furnish at least one man, the widows joining the expedition as cooks. Sticks and large coils of string are taken. In a suitable plain the sticks are driven into the ground twelve to fifteen paces apart, and joined together by the string at about twenty-eight inches from the ground. In this manner a circular space of about a mile in circumference is enclosed, leaving, however, an opening on one side a few hundred paces in width. The women then tie to the string pieces of bright-coloured rags which flutter to and fro in the wind. As soon as everything is ready, the men, a third part of whom are on horseback, scatter in every direction, and for many miles drive the vicunas into the ring, which is closed as soon as a sufficient number have been collected. The timid animals dare not jump over the string with its formidable array of fluttering rags, and are easily killed with the *bolas*. These weapons consist of three balls of lead or stone, two heavy and one light, fastened to long strings made of the nerves of vicunas. The strings are tied together at the free end. The lighter ball is held in the hand, and the heavy ones swung in circles round the head. At a certain distance, namely, twenty or thirty paces from the object aimed at, the ball held in the hand is let loose, and all three whiz through the air in circles to the destined mark, and wind themselves round the victim which they strike. The aim is generally directed to the hind feet of the vicuna, and the bolas tie them so firmly together, that every movement is impossible, and the animal falls. Great dexterity and long practice are required to use the bolas aright, especially on horseback, for the novice not unfrequently inflicts upon his horse or himself a fatal wound. The vicunas captured by the bolas are immediately killed, and the flesh distributed impartially among all present. If a guanaco is driven into the inclosure, it either breaks the string or leaps over it, and then all the vicunas follow, so that great care is taken not to allow any of the former animals to enter the ring. As soon as the vicunas are killed, the string is untied and rolled up, and the stakes are planted a few miles farther off. The whole chase lasts for a week, and the number of animals obtained in the expedition amounts sometimes to fifty and occasionally to several hundred. A five days' hunt is said to have resulted in the capture of 122 vicunas.

The alpaca (*Auchenia praco*) fills the place of the sheep, and yields, like the latter, both wool and flesh; the former is an important article of commerce, and is largely manufactured in Europe. The attempt to acclimatise these useful animals in Scotland and Australia has proved a failure. The guanaco (*Auchenia huanoco*), the last member of the lama tribe, inhabits a larger area than the other animals; as large as a stag, it represents the alpine chamois in the Cordilleras from the north of Peru to the islands of Terra del Fuego; and in Patagonia, where it is found in the greatest numbers, it scours the pampas with the jaguar and the nandu.

The home of the guanaco is also that of the condor (*Sarcorhamphus gryphus*), a giant vulture, measuring seven to eight feet across the extended wings. It is found principally in the Andes, 9,000 to 15,000 feet above the sea level, while in Patagonia and Magalhaen's Straits it builds its eyrie on the steep crags immediately above the coast. In Peru and Bolivia also it often descends to the coast, but it is found in ten times the number on the heights that it is in the valley. Humboldt relates that it is often observed hovering above Chimborazo, 21,000 feet above the sea. During breeding time the birds live in pairs, but at other times in companies, choosing out steep, rugged cliffs for a resting place, and regularly returning to the same spot. In flight they rise with loud flaps of their strong pinions, and then glide smoothly onward without moving a wing. When one of them sees anything eatable, it swoops down upon it, and all the others follow. "It is incomprehensible," says Tsitudi, "how in less than a quarter of an hour clouds of condors assemble round some tempting bait, when not a trace of them could be detected before by the keenest sight." Like all other vultures, the condor is especially an eater of carrion. According to Humboldt, two of them together will pursue not only the stag of the Andes and the vicuna, but even the guanaco and calves, circling round them and wounding them till they fall; and they are known to follow both wild and tame herds, and to pounce down in a moment upon a dead animal. In some cases they attack galled horses which are unable to defend themselves, and are forced to endure the torture inflicted by the birds, who tear the flesh round the open wound. The hunter, in disembowelling his prey, is always attended by flocks of vultures, which alight with greedy haste upon the refuse, and show not the slightest fear of man. They are said to follow in like manner the jaguar in his chase, and to carry off the remains of his repast. When the condors alight, and then suddenly rise up all together, the Chilian knows that the puma has scared the pirates away from the prey captured and slain by himself. By the seashore the birds feed on the large sea mammals cast ashore by the tide, of which such numbers are found in South America. They avoid the dwellings of human beings, and never attack children. The latter often sleep on the mountain heights, while their fathers are gathering snow, without being disturbed by any fear of the piratical attacks of the condor.

In the south of Peru, especially on the west coast of South America, beyond the tropics, there is still to be found perhaps the most beautiful of all swans, the black-necked swan (*Cygnus nigricollis*), whose dazzling white body presents such a magnificent contrast to its black neck, pale pink feet, and bright red beak.

Very familiar is the story of the difficulties which at the beginning of the seventeenth century embittered to the Spaniards their possession of the fair and fruitful countries of Chili and Peru. These difficulties arose from the unhealthy climate and the prevalence of the intermittent fevers which haunted the coast regions, proving fatal to thousands of Europeans after a few months' or years' residence in South America; and yet the healing plant, cinchona, or Peruvian bark, was close at hand.

FLOWERS AND FRUITS OF THE CINCHONA TREE (*Cinchona condaminea*).

The genus Cinchona belongs to the family of the *Rubiaceæ*, or madder growths, and is nearly akin to the coffee plant, and to our own wood-roof. They are fine tall trees, only a few of them remaining as shrubs, with trunks from 12 to 18 feet high, and 25 to 75 inches in diameter, bearing aloft a crest which rises much higher. Occasionally trees are met with 90 to 120 feet in height. The large leaves are bare and glossy, the flower leaves and the under-sides of the younger leaves are often of a beautiful red tint. The flower is of a fine rose colour, shading to white. The genus is a very large one, and the number of species has been estimated at from forty to fifty.

The region of the Peruvian bark forms an arched tract of land on the eastern slope of the Andes, which extends from 19° S. lat. to 11° N. lat., and is therefore more than 2,000 miles long. The different kinds of bark are generally divided, according to the prevailing colour of the inner surface, into yellow, brown, and red. The best yellow bark is obtained from the southern part of the region in Bolivia, the brown from the central division in Peru and Ecuador, the red bark round the Chimborazo, and finally, an inferior yellow kind is grown in the north, at New Granada. Immediately above the region of palms and bananas begins along the mountain slopes that of the tree-fern, together with that of the cinchonas; but the latter extend much higher than the tree-fern. The good kinds seldom descend below 6,000 feet, while they rise to 10,000 feet above the sea level, in other words, to the limit of tree growth. It is seldom that the cinchona trees form entire forests; they are generally found in groups, and still more frequently standing alone. They are said to affect the true cloud region of the Andes chain, where, in the rainy season, which lasts for nine months, constant rain alternates with dense fogs, seldom relieved by a few moments of sunshine during the daytime. In the season corresponding to winter, cold nights set in, lighted by the quivering gleam of myriad stars, and during which the temperature falls below freezing point; whereas by day, when the heavy mists lie upon the foliage, drenched with perpetual dew, the temperature rises to 77°.

The *cascarilleros*, or bark gatherers, are generally Indians, who collect the bark by felling the trees, and then stripping off and drying the bark. Two men are required to fell one tree ; and a tree of sixty feet high, and four feet in diameter, yields about 10 cwt. of dry bark. But although thousands of trees are destroyed in this way every year, yet there is little fear of extirpating this useful tribe, as numbers of shoots spring up from the stumps of the felled trunks, and grow into new trees.

Equatorial Brazil.

Hylæa.

In our temperate zone, meadow-lands generally mark the river valleys, and the most widely distributed tree is the willow in its various forms. The weak blade of the grass is of annual growth, and dies as soon as it has brought its seeds to maturity. There is therefore no room for meadows where tropical warmth and an uninterrupted water supply allows of a constant development of plant life; in such circumstances nothing can resist the expansion of the trees, since their growth is only limited by their period of duration, and their vegetal force is greatest. Thus the river Amazon, which has the greatest volume of all the rivers of the globe, has called forth along its banks a mighty forest region to which Humboldt gave the name of Hylæa, Here the phases of development, as manifested in the blossoming time of the several species, are distributed throughout the whole year. The species do not fare alike in this respect, and a botanist who relaxed his labours for only one month in the year would lose several trees every time. There is also a periodicity of plant life, which is explained partly by the unequal distribution of rain throughout the year, and partly also by the varying height of the rivers, and the consequent relative position of the ground water to the roots of the trees.

The superabundant diversity of plant forms crowded together near the Amazon forbids any satisfactory reply to the question as to what the forests are composed of. More species of a tribe are found collected within a narrow space, than can be obtained from the whole forest flora of Europe. One kind, one variety, thrusts aside another, and not even the smallest areas are filled with plants of only one genus. Every day, every change of locality reveals new forms to the traveller. In the temperate zone, both in Europe and Northern Asia, the woods are named from the trees of which they are chiefly composed, and we speak of oak woods, beech woods, birch or fir woods, sometimes also of composite woods, where conifers are found growing among non-coniferous trees. Such uniformity as this is wholly foreign to the forests of the tropics. Our forests have a character of their own ; their grand simplicity exerts a soothing, calming influence upon the restless wavering spirit, and offers no hindrance to the free play of bodily movements. Different indeed is the tropical forest. It breaks up all idea of unity into a thousand details ; the attention is arrested and claimed on every side, the mind is shaken out of its repose, thought is withdrawn from its silent musing, the very senses are brought under the spell of constant distraction and emotion. Every tree and shrub is striving to wrest away the place held by another; forest rises above forest, the different kinds of wood, roots, bark, are wholly distinct one from the other, and the manifold gums and balsams exhale countless fragrant essences. Every step and motion is impeded by the dense tangled undergrowth, by a confused interlacing of pliant rods, thorny vines, and bramble, a chaos of clinging roots and branches, swaying aerial roots descending rope-like from a dizzy height, lianas with stems as thick as a finger or an arm winding upward in serpentine coils round the unbroken trunks of trees 90 to 100 feet high, swinging in festoons from bough to bough and crest to crest, descending to the ground itself, and rising again to the forest roof. Every shrub strives to develope into wood, blades of grass and stalks of fern and shrubs become bush, stem, and tree: the forest is a dark massive labyrinthine thicket, which the axe has scarcely power to enter or to penetrate. And it is just this, as Humboldt says, which constitutes the true character of the tropical forest. For the name primeval is scarcely merited by every forest upon which man has not laid his hand, either to cultivate or to destroy, or else the phenomena would be shared by many districts, both of the temperate and the frigid zones. Neither is it the fibrous, climbing tendrils of the lianas, which, as is so often and so untruly said, create the impenetrable nature of the forest, for they often compose only a very small part of the undergrowth. The principal hindrance is formed by the shrub-like plants which fill up every available space, and as they are reached by the two great requisites of almost daily rain and intense heat, develope into woody growths. The banks of the rivers which flow through these forests are not unfrequently fringed by impenetrable walls of thorny plants. In front of an almost unbroken wall of giant stems (*Cæsalpinia*, *Cedrela*, *Desmanthus*,) rises with great regularity along the sandy shore a low hedge (*sauso*) of about four feet in height, and composed of a small shrub (*hermesia castanefolia*), a genus of the wolf's-milk order. A few thorny palms, named by the Spaniards *Piritu* and *Corozo*, probably of the *Martinezia* and *Baktris* tribe, grow close to the hedge. The whole thing looks like a well-trimmed garden hedge with a few large gate-like openings at wide intervals leading from the river into the interior. These openings are evidently made by the larger beasts of the forests, the jaguar, tapir, and others. For the wild animals are always obliged to wander along the same road, and therefore the gateways are much older than the plants by which they are surrounded: the latter are renewed, but the gate remains. Nothing speaks more strongly for the impenetrability of the forest, than such phenomena as these: if one of the larger animals, when coming down to drink or bathe, is surprised by the appearance of a canoe, it never attempts to break through the dense thorny growth of the sauso wall, but trots slowly away between the wall and the river, and disappears up the nearest opening.

When Humboldt, seated in his narrow canoe, journeyed for seventy-four days up the Orinoco, Casiquiare, and Rio Negro, traversing principally by water 1,520 miles of country, he was never weary of contemplating the curious spectacle, which repeated itself often. Creatures belonging to the most opposite classes of animal life came down in groups to the water's edge to bathe, drink, or fish; the great mammals being accompanied by bright-coloured herons and proudly strutting hokko-fowl. "Things are carried on here as they were in the garden of Eden," piously said the steersman, who had been brought up in the house of a priest. But the sweet peace of the golden age is banished far from the Eden of the American animal world. The different creatures separate themselves, spy and shun each other, and the water hog, or *Capybara*, an animal three feet long, a gigantic reproduction of the common Brazilian sea-pig, is devoured in the water by alligators, and on land by the jaguar. The manner of life of the latter animal is an additional proof of the impenetrability of the forest. While the carnivora of the llanos and the pampas are well supplied with food, and have been multiplied to a considerable extent since the introduction by Europeans of tame cattle, horses, and mules, with which, ever since the discovery of America, they have waged an unequal war, other members of the same family lead a precarious existence within the depths of the great forests. The jaguars, said an Indian of the Durimunda tribe, driven by hunger, stray into such impenetrable recesses within the wood, that they cannot hunt along the ground, and are compelled to live for long periods of time among the branches of trees, a terror to the monkeys and opossums.

Notwithstanding the immense mass of leaves, which prevent any direct ray of light from reaching the ground, the mysterious darkness of our northern woods never reigns within the primeval forest; on the contrary, the whole confused world of leaves and boughs seems bathed with that softened gleam, so difficult to describe, but so characteristic of tropical scenery. The light cast by the myriad but principally refracted sun rays is strong enough to admit of a rich plant-life springing up, even in the shadow of the leafiest branches; and to effect in their respective organisms that transformation of substances which directly depends upon light, especially the conversion into organic matter of the various inorganic particles of nutriment received by them. And this strange and wonderful gleam is not to be attributed only to the vertical rays of noon, it remains almost unaltered throughout the whole day. In the northern woods the shadow is brightened by the light which penetrates through the leafy crests, but in the tropics, where most of the trees have evergreen leaves, thick and opaque, but glossy, the darkness of the lower forest region is only illuminated by refracted light. Countless waves of light fall from above, between the pyramidal masses of foliage, and break in every direction, thrown back from tree to tree and leaf to leaf, reaching the deepest recesses at last as a pale radiance, and conjuring into life the vital powers of every organ in the plants found upon their way. And tropical nature, besides the reflecting surface of the foliage, has arranged another method of formation and distribution for this free play of light, and one which is essentially different from anything in our northern woods.

In climates where either cold or drought necessitates a winter sleep for trees and plants, as is the case in the forests of the temperate zone and the savannahs of the tropic zone, the trees develope during their short time of sprouting and putting forth shoots a far greater number of small branches, which form an unbroken, although on the whole a more open, roof of leaves than that of the constantly warm and humid forests of America. Besides which, in the winters of the temperate zone, the tips of the widest spread branches are apt to die and be renewed by fresh growth, which takes the form of new branches and subdivisions, producing a continual distribution of branches of equal size. The leaf-roof so formed therefore overshadows the ground, without leaving any open spaces. But in the moist climate of the tropics the restless upspringing of a short season of plant growth is altogether unknown; and the boughs, nipped by no frost, grow toward the light without ever swerving aside, thus allowing of greater or smaller intervals between the crests of foliage. The radiating growth of the palm, whose leaf-crown springs forth from a central point in every direction, like the rays of a circle, and is only subjected, in the formation of its downward curve, to the laws of gravity and elasticity, may be considered as the typical model of tropical vegetation. The rapid irresistible growth upward, affecting chiefly the tree trunk, and only sending forth as many side shoots as are necessary for the welfare of the tree, or the formation of the requisite number of leaves, favours the formation of an upper roof of foliage much more open, and capable of admitting the light, and allowing it room to penetrate freely; and produces that appearance of lightness and grace which is so remarkable in these giant forms. The wealth of leaves does not rest like a heavy burden above the head of the spectator, but soars free and joyous in the blue tracks of ether, and seems to float there unfettered in a sea of light.

Not only the boughs of the giant trees, but every branch and spray on shrub and bush, down to the very smallest, exhibits this fundamental radiating system of growth. Everything strives upward from the ground towards the source of light; lianas, ferns, and a hundred parasitic plants fill up the spaces through which the blue-eyed vaults of heaven gaze curiously down into the mysterious forest depths, until high overhead one sees a garden of climbers, shrubs, and plants, growing far out of reach. Fresh life shoots forth from the branches of the trees, or from the myriad living garlands waving between; while the hand can only grasp the leafless rope-like stem of the liana, which carries the nourishing juices of the earth, to its hanging bushes 100 feet above.

It is often impossible to tell whether the large brilliant flowers seen in the crests of the trees belong to the latter or to some climbing or parasitic plant; the more so because in the tropical forest the European traveller often looks with amazement on the, to him, unfamiliar sight of great trees, larger than the oaks and beeches of his native land, adorned with the most beautiful blossoms. And yet, in all this fermenting, inexhaustible fulness of life, the high expectations of the foreigner respecting the wealth of colour, tone, and vitality, the splendour of the flora, the abundance of fruit, the exotic wonders, and the animal life of the tropics, are generally disappointed. The fairest pearls of the tropical flora are as a rule withdrawn from view; they are not woven with lavish hand among the verdure of the woodland floor, but scattered like solitary grains of gold, and carried out of sight, to the highest crests, where they are twined in a gay and brilliant garland. And it is the same with the moving animal world as with the vivid floral life. The glittering winged insects, the bright-plumed parrot tribe, the flying game and its pursuers, assemble only in the more open spaces, or hover in the fragrant bell of some great flower calix far above the gloom-filled depths below. Thus, in the heart of the forest broods a deep, melancholy hush and loneliness; voiceless silence and stirless calm reign all around, a dim, mysterious twilight, broken only where through the leafy rifts above the daylight falls, and is scattered in fantastic gleams and reflexions.

Where the united forces of heat, moisture, and the fertility of the soil are not enough to create an unbroken forest of giant trees, and the latter are seen rising far apart, above lower or medium vegetal forms, the impression made by the evergreen forest upon the European is one of confusion and disorder, and more than half its charm is lost. Its impenetrability, produced now by the riotous luxuriance of the undergrowth, is the same, and it seems as if the free growth of the tall trees was checked and hindered by them. If the isolated trees are not sufficiently covered with creeping plants, one is inclined to look upon the "floating in the air" appearance of their highest crest as a mutilation, whereas it is the exact contrary: the crests need wider branches, the foliage clings to them in dense and almost distorted growth, the perfect leaf-crown is wanting, the wide gaps impress us painfully, and the tree often points as with extended fingers heavenward.

But this might be forgiven if the strange-looking crests possessed the dainty symmetry of the palm, and an even, elastic pliancy of the branches yielded harmoniously to the universal law of gravity. But this is seldom the case. Often, however, the climbing plants form a luxuriant growth round the giant tree, and cover it entirely: new creepers twine above the old and dying; an absolutely impenetrable roof, a very hill of vegetation, arises, and the splendid tree which has defied centuries, is stunted, and gradually sickens and dies, falling to the ground with all the greenery which had grown upon and around it. Scarcely has the crashing thunder of its fall died away, when a mysterious noise, low groaning and sighing, a creaking and tearing, is heard from the neighbouring bush. The bush itself seems to move, to swerve outward from its centre, the leafage rises from the ground; a creeping, gliding, and trampling is caught by the startled ear; it comes from some bough or branch overloaded with its burden of plants, thrust aside from its place, and slowly altering its position, carrying with it its whole surroundings in gentle movement. And after a while even these noises die away, and a death-like stillness closes again above the forest. But if the wanderer, tired out at last, looks for a resting place, he finds no cushion of velvet moss, no soft couch of flowers upon the fragrant turf for the fairest ornament of the northern woods; the flower-embroidered carpet of moss and turf is all unknown within the fiery forests of the tropic zone.

The temperature within the interior of the primeval forests is many degrees lower than that of the rivers or the burning sandbanks and rocks rising above the water. In the latter places the thermometer, even in the shadow of a wide open tent, rose in the afternoon to 104° Fahr. A temperature like this is felt the more unpleasantly, because in the early dawn the air has generally a temperature of 68° and even 57°. The traveller artist, to whom our illustrations are due, describes the effect of the latter temperature as being exactly the same as would be experienced in Europe when the reading was several degrees below freezing point, so that in spite of his being wrapped up in a warm mantle he was scarcely able to hold his pencil.

The best pathway into all these varied splendours is offered by the broad bank of the noble river Amazon. The incoming sea does not accept tamely the defiance of this giant stream. Ocean and river rear themselves aloft one against the other, and the Amazon would scarcely be navigable from the sea, if it were not connected by perfectly calm channels with the waters of the Gran Para. Here we are surrounded by genuine tropical phenomena. Along the distant shore, stem by stem in serried rank, the beautiful Mauritius palms (*Mauritius flexuosa*) rise in thousands above the stream, all exactly alike, about eighty feet high, the stems expanding slightly at the top, and bearing a few colossal fan-shaped leaves, two or three of which are a heavy load for a man; between the leaves hang large clusters of fruit close to the stem, and composed of from 120 to 200 glossy cone-shaped fruits. The whole tree presents a picture of the greatest strength, fulness, and vitality; for the fruits contain a floury, edible meal, so that Spanish missionaries have called the palm the tree of life.

The river carries us on among the wonderful woodland lagoons. The mirror-like dark-green water is framed in perpendicular walls of green forest trees. Down from the verdant heights hang bignonias with exquisitely fragrant blossoms, and asclepiads with splendid flowers of the richest colouring. Here and there upon the quiet waves float perfect meadows of pontederads, among which rise the blue petals of the water hyacinth. As our keel creates a certain commotion in the waves, a whole chaos of whirring insects rises with startling suddenness from the floating island, especially butterflies and humming-birds, many of the latter shewing beautiful coloured wings. Behind the blue blossoms of the pontederad meadows floats a fair grove of tall-stemmed aroids, as an attendant on their course. The *Caladium arborescens* forms a reedy stem nine to twelve feet high, crowned with a tuft of arrow-shaped leaves, between which the white-flower pyramid is seen growing as in the case of the *Kalla.* High above the aroids towers a fringe of arrow-grass (*Gynerium saccharoides*), a tall strong cane, bearing aloft its burden of divided leaves, above which rises to the height of sixteen feet the elegant flower cluster which furnishes the Indians of the great river with the material for their slender arrow shafts. Impossible as it seems to disentangle the woodland chaos behind these outposts of vegetation, we must nevertheless pause to examine a few forms. Here and there we distinguish one of the largest leaf surfaces of tropical vegetation. It is the leaf of the Bussu palm (*Manicaria saccifera*). On a short well-knit stem six to eight leaves rise sharply upwards, and each leaf has an unbroken surface of twenty-four feet long and four feet wide, perhaps the extremest measurement existing in leaf nature. A little deeper within the wood we find much larger leaves, but they are feathery, and belong to the *Jupati* palm, the short, compact *Raphia tædigera.* Here, too, the leaves stand up straight, a splendid toy for the wandering breezes. We sail round a fragment of forest which lies straight in our path, and the scene changes as at the stroke of a magic wand. All has vanished, the dark mirror beneath our keel, and the lofty forest wall beside us : in their place a foaming watery chaos tears us along ; driftwood from far and near is tossed onward toward the east; the temperature has suddenly fallen seven degrees, and above in the tree tops a fresh breeze is blowing, while immediately below the clouds the wide-winged frigate birds (*Tachypetes*), the boldest aerial sailors of the world, wing their circling flight ; gulls and sea swallows fly around us. Such is our greeting from the Amazon.

The first glance at the river shews us that it is no kindly neighbour for the culture which rises trustfully on either bank. Indeed, it is only in a few of the higher-lying districts that any kind of hamlet or settlement can exist in safety. For one of the chief characteristics of the river, and the cause of its dangerous influence on the shores, is the extremely high rise of its surface. When, in our northern spring, the Amazon has reached its high-water mark, its waves are forty to sixty feet above its lowest surface level, and the forests along its banks are lying under water for many miles round. All the animal life seems to have disappeared, and all movement has disappeared even from the crests of the trees. Then, in the beginning of June, the flood begins to go down, slowly at first, and often very rapidly after a while. The immediate consequence of its sinking is a work of wide-spread destruction. Palms, giant bertholletias and cedrelas hang over the banks in a threatening incline. With fear and apprehension even the Indian passes beneath them in his light canoe. A dull cracking at length heralds in the catastrophe. The whole bank, with its covering of forest trees, extending often for an almost incredible distance, falls crashing and thundering into the river. Countless uprooted tree trunks drift along, to the serious danger of the vessels on the stream. But soon the river presents a more peaceful picture, and the living creatures come back to its waters. Tree-crests and sandy shores, dry land and water, rushing river and stagnant pools swarm with the most wondrous animal life; for here the existence of bird and beast is divided strangely between land and water. Many more mammals live upon the trees and in the water than upon dry land, and even of the land animals many frequent the water, and seek it often and voluntarily as a second element.

The bird world is chiefly represented by a number of climbing birds, which rather climb from branch to branch than pass through the air in a wider flight; or, like the herons and sandpipers, take to the water and swim about upon the surface, always in the closest relationship to the all-nourishing stream. It is an amphibious life unequalled in zoology. In the early dawn, when, after a short twilight, the sun rises swiftly above the forests, we hear a

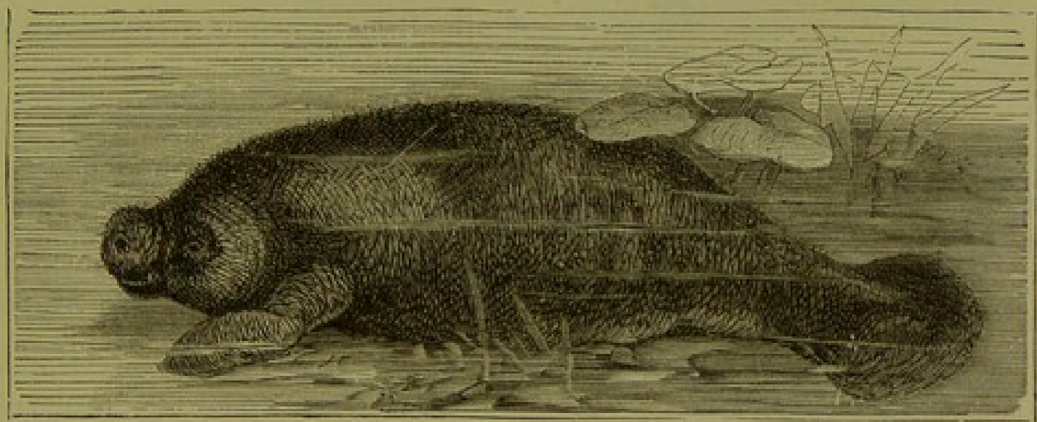
FALL OF TREES FROM THE BANKS OF THE AMAZON. ALLIGATORS IN THE WATER.

loud, hollow screeching, sent down to us from the branches of the giant forest trees, and we see above us the giant parrots, the bright-coloured arara, and the ararauna, blue plumed and red breasted, gorgeous to behold. Beside them sport the Amazon parrot and the long-tailed parroquets, especially the yellow blue-fringed *Conurus luteus*, which loves to clamber up the projecting jar-shaped fruits of the great *Sapucaias* (*Lecythis ollaria*), and fight with the nimble monkeys for the almond kernels. Little parroquets alight in flocks upon the Humboldt willow, quarrelling as noisily as sparrows. We must not forget the toucans, with their unconscionable length of bill amounting almost to a monstrosity, the Brazilian woodpeckers, and other birds resembling them in their manner of life. Here and there long stretches of the shore are framed in silk-cotton trees (*Bombax*), belonging to the few plant forms of the Hylæa, which periodically shed their leaves. The forest looks bare. But in a short time numberless blossoms break forth, sometimes large and beautiful red, deeply cut crown of flowers, sometimes delicate white blossoms. When the flowers have fallen off, a large scarlet, almost cucumber-shaped seed capsule, which as it bursts open discloses an immense quantity of silky shining cotton, sometimes copper coloured, sometimes pure white. Very often the *Paineiras* and *Mongubeiras*, as these trees are called, are adorned with wholly different kinds of flowers, and loaded with numerous fruits, and a number of pendant nests; they are frequented by busy troops of bright-coloured birds.

ARARA (*Sittace*) AND FAN PARROQUET (*Pionsas accipitrinus*). Length, 12 inches.

The tapir is the largest mammal, and the principal object of the chase. This dwarf representative of the elephant is found in great numbers, without, however, assembling in herds upon the closely wooded shores of all the affluents of the Amazon and La Plata, preferring the marshy lowlands and the plateaus, with their scanty water supply, to the luxuriant vegetation of the valleys and ravines. In the impenetrable thickets of the shore, under the feathery roof of slender tree-ferns, he loves to make his home, whether it be upon the banks of rushing broadland brooks, or by the foaming cataracts of giant streams. At the first blush of dawn he advances to the river to take his bath, and often the traveller comes unawares upon the pachydermous animal sitting quietly up to his neck in water. If the tapir is a true specimen of the amphibious mammal, the animals which range next to him as the most widely distributed are of a fish-like nature. First comes the *peixe-boi*, or ox-fish, which, in defiance of its name, is as little of a fish as its gigantic cousin, the whale. It measures nine feet in length, and is known as the lamantin (*Manatus Australis*), whose tender flesh, resembling pork, is much sought after, and considered one of the delicacies of those regions; in consequence of this, its ranks have been considerably thinned, while the *Inia Amazonica*, a creature of the dolphin tribe, rejoices in immunity from all attacks. Notwithstanding the ease with which it can be harpooned, and the valuable oil which it yields, it exists unmolested; for "it has the power of assuming human form, and walking about like a Christian." In these cases it is particularly dangerous to the fair sex. At the present day these creatures are a traveller's most faithful companions, and follow in the wake of the ship in shoals. It is a curious sight to see them coming to the surface from time to time to breathe the air, often leaping out of the water by the means of their broad tail fins, to fall back again with much snorting and blowing into the liquid element.

Although these forests contain neither elephants, rhinoceroses, hippopotami, giraffes, antelopes, nor any of the other nobler game which attracts so many a Nimrod to Africa, the sportsman will find even here plenty of booty, for many more must be added to the mammals already mentioned. First of all, as representative of the lion, comes the ounce, or the jaguar, the most dreaded of the carnivora of the New World. Not that he exists in great numbers, but that he is dangerous to all. Only a few vultures, black *urubus*, contend with him for the prey. "The animal lay stretched out in the shadow," writes Humboldt, "his paws resting upon a water hog which he had just killed; a number of vultures had collected round this American king of beasts, ready to consume whatever might remain over from his repast; they approached the jaguar to within about the distance of one or two feet, but the slightest movement on his part was sufficient to scare them



LAMANTIN (*Manatus Australis*). Length, 9 feet.

away. The splash of our oars caused him to rise slowly, and retreat within the bush; the vultures profited by the opportunity to devour the water pig, but the jaguar suddenly sprang in among them, and glaring angrily carried off his prey into the forest." This animal will reject no flesh except that of its own species; this at least is the general belief, because jaguars kept in a state of captivity always refuse the flesh of dead jaguars. They attack not only the mammals, deer, porcupines, pacas, peccaries (*Dicotyles torquatus*), (*Dicotyles labiatus, Coelogenys*), water pigs (*Hydrochœrus*), agoutis (*Dasyprocta*), and coatis (*Nasua*), but have learnt the art of laying an ambush for the marsh birds in the sedge, and skilfully catching fish from the waters. They are the deadliest enemies of the turtle, following her to the shore where she lays her eggs, pouncing upon her in the sand, and turning her over, so as to be able to devour her more conveniently. They display a horrible dexterity in emptying the double armour of the turtle shell, the operation being performed as if by the aid of surgical instruments.

The only kind of land mammals which are unmolested by the jaguar are the sloths, who probably owe their immunity solely to their tree life, the nimble squirrel tribe, and the monkeys. Of the latter animals, four species, namely, the spider monkeys (*Ateles*), long-tailed monkeys (*Pithecia*), short-tailed monkeys (*Brachyurus*), and woolly monkeys (*Lagothrix*), are restricted entirely to the forests of the Amazon. More familiar than these in our zoological gardens are the favourite little squirrel monkeys, lion monkeys, silver monkeys, and others (*Hapale rosalia*, *Leonnia*, *Ædipus*, *Argenteus*, and *H. jacchus*), together with the howling monkeys (*Mycetes*). The latter are distinguished by a bony drum under the tongue, which catches the air.

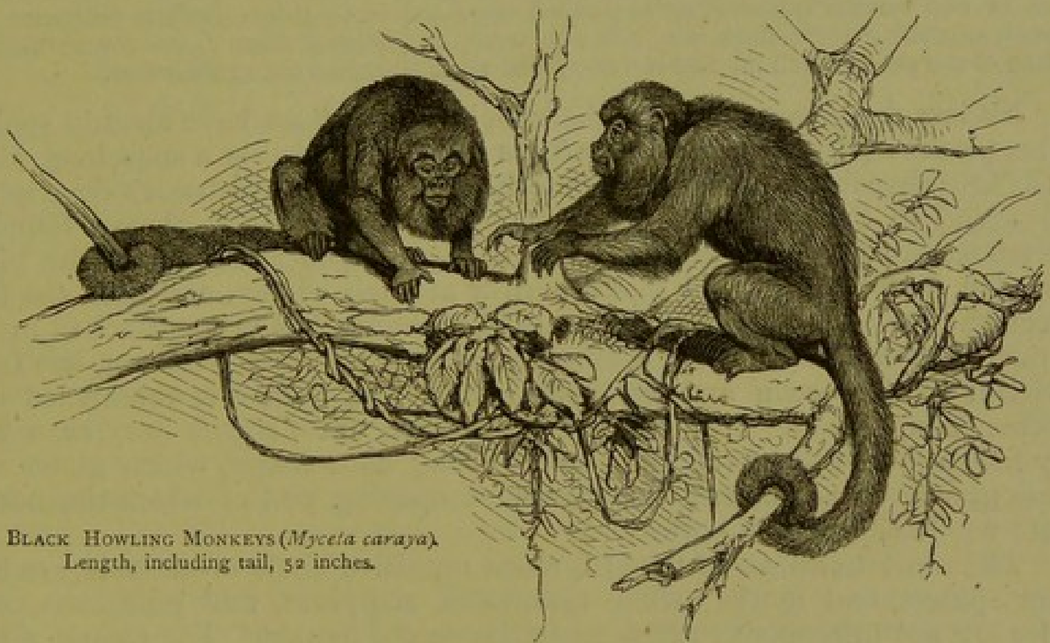
"Before me, on the branches of a high tree," writes Schomburgk, "sat the howling monkeys, performing such a terrible concerto that might well make one believe that all the wild beasts of the forests were waging deadly war one against the other. At the same time it must be confessed that a kind of grim harmony existed in the performance; for suddenly, as if at the fall of the conductor's bâton, the whole chorus seated upon the tree was hushed; after a while a solo singer broke out unexpectedly in a discordant howl, and the whole piece began over again. For a moment the sounds resembled the grunting of a pig, then all at once they changed to the roar of the jaguar pouncing upon his prey, to sink after a while into the low, ominous growling of the same animal when surrounded on all sides it sees itself brought to bay. This terrible performance had, however, its grotesque side, and even the face of the gloomiest misanthrope must have been beguiled into a smile while watching the intense solemn gaze with which the long-bearded vocalists stared at each other."

THREE-FINGERED SLOTH (*Bractypus Trydactylus*).
Length, 20 inches.

Both Brazilians and natives are eager in the chase after monkeys, much more so than Europeans, who generally feel their pleasure in the sport destroyed by the piteous screams of the wounded creatures, their almost human gestures, and their hasty clutch at the bleeding wound. But there is rich compensation for the European sportsman in the number of gallinaceous fowls, among which the jaku fowl and jakutingas (*Penelope*), mutungs or hokko fowl (*Crax*), and the rare aniuma (*Palamedea cornuta*), are the most worthy of note.

Here and there a woodpecker taps the hollow tree trunk, and the dull stroke of its beak is a welcome break to the melancholy silence in which the forest lies folded. From the dense leafy crown of the giant fig trees and the so-called cedar trees rises unlooked-for the wild shrill cry of the *Harpya destructor*, the largest and wildest eagle of South America. Suddenly the advancing step is arrested by an appalling tiger-like roar, which is, however, of perfectly harmless origin, and is emitted from the breast of a yellowish red bird of the heron kind, spotted with black, innocently standing in the hidden swamp hard by. Countless flocks of cassikoos send forth melodious, bell-like tones, in short, broken cadence, sounding now nearer, now farther off, in pure, tuneful intervals. Like the sound of resonant metal, the cry of the bell bird (*Chasmarhynchus carunculatus*) strikes upon the ear, or the "organist" (*Cyphorinus cantans*) of the forest minstrels sings his merry song with a clear sweet voice that sounds like the notes of a flageolet. Curiously the oriole peers from its purse-shaped nest, and tries to imitate the different voices which rise around him on all sides. White herons stand motionless along the coast, red ibises move in long files sea-ward, and in majestic repose the tall spoonbill (*Cancroma cochlearea*), and the stork (*Mycteria Americana*), survey their wide hunting grounds. Like a pleasant dream the humming-bird hovers above the fragrant chalice of a flower.

Several hundred kinds of fish are known; indeed, the extraordinary wealth of the rivers, and the superabundance of game, seem to afford a natural explanation for the decided preference shewn by the Indians and Mestizoes for fishing and the chase, in comparison with the rare and sadly neglected breeding of domestic animals. For although the ox is not now as it was a short time ago, altogether an unknown denizen of the lowland plains, with their covering of woodland and scarcity of grass, yet it is even now very rare, and its flesh is an unattainable dainty for the solitary savage or half-breed, since the small number of cattle brought by steamer up the River Amazon is scarcely sufficient for the needs of the little towns. The coloured tribe stand motionless for hours together, harpoon in hand, watching for the giant piraruku (*Sudis gigas*) a fish nearly twelve feet long, and for the thorn-



Black Howling Monkeys (*Myceta caraya*).
Length, including tail, 52 inches.

back (roach), whose long tail, armed with a bony spear, and measuring several feet in length, is not unfrequently dangerous to bathers.

Everything is fair in fishing, every means of capturing the scaly monsters of the deep is used by their enemies; not only harpoons, hooks, bows and arrows, nets weighted with lead, and long drag nets, but in many places whole tribes join together and build up a stone dam, so as to force the fish to pass through one narrow opening between the reefs of a rapid, and so to fall into the nets spread to receive them. Along the wide stretch of sandbanks on the shallow shore, the Moxa Indian waits for the serried shoals of small fish driven up the stream at certain periods of the year; standing up to his knees in the water, he throws the *covo*, a beautifully made cylindrical basket plaited with osier and heavy palm wood, and quietly empties it of its load, taking out the fish with his hand, through the narrow opening at the top of the basket. Lastly, in certain cases where the shallowness of the water admits of it, as for instance in small lagoons and standing pools left by the retreating tide, recourse is had to the poisonous juice of certain plants, especially that of the liane (*Paullinia pinnata*), which is crushed and squeezed out into the water to kill, or at least to stun the fish, a method which, if it could be used on a large scale, would soon seriously compromise the yield of fish obtained from these rivers, however enormous it might be, since young and old, bad and good, are alike sacrificed, and the greater part of the booty falls to the lot of the carrion vultures.

On one occasion, the traveller, Keller Leuzinger, confesses that he would have made use of the poisonous juice without scruple, if the liane had been within his reach. In a natural basin, separated from the river by a high ridge of rock thirty feet wide, hundreds of great fishes left stranded by the tide were slowly dying a terrible death in the warm waters of the pool, laden and defiled with every kind of putrefying matter. He counted more than five hundred dead fish in every stage of decay, floating about upon the green slimy surface of the pond, and poisoning the air around to a considerable distance. Every now and then an immense *Surubim*, a species of *platystoma*, with long fins, rose from the depths, and slowly, as if half-stupefied, moved through the muddy liquid. Notwithstanding the loathsome nature of the sight, Keller Leuzinger had much difficulty in restraining the Indians from harpooning and eating the half-dead fish; while rigid and motionless, as if cast in bronze, a dozen or two carrion vultures (*urubus*) stood upon the rocky ridge, like the pinnacles of a fortress, spreading their dark wings to the wind, and gazing down upon the mouldering surface of the pond which lay like a well-spread table stretched out at their feet.

No less dangerous than the thornback, of which we have already spoken, is the piranha (*Pygocentrus Richardii*), a broad fish, barely a span long, allied to the Caribbee fish (*P. nattereri*), so well known from Humboldt's description, and found in the waters of the Venezuelan llanos. It is always found in companies of several hundreds; and as soon as the water is tinged with blood from the first bite, they all make a rush at their victim, and tear the flesh piecemeal from his body. Many a bold swimmer has been attacked in this manner, and literally devoured alive by the terrible little creatures, has fallen a victim to the ocean and its inhabitants. The bather is threatened with another danger, and of a different kind, from the *Cetopsis candiru*, a thin, tiny fish, almost transparent, and not so long as a finger, which glides with the dexterity of an eel into the narrowest opening, and of which the natives relate whole chapters of horrors.

The most harmless of the still more repulsive kinds of animals are bats, giant spiders, and moths; while tarantulas, scorpions, and poisonous centipedes are not infrequent guests, especially in old houses. The *Giboia*, a kind of large snake, is kept tame in many houses, expressly for the destruction of these insects and reptiles, and of the swarms of rats and mice. Less than might be expected is heard of venomous snakes, but the bite of the *Surucuru* (*Lachesis muta*) is in every case dangerous to life. The different kinds of jararaca (*Bothrops*) and the coral snakes, though capable of causing serious illness by their bites—for instance, a mortification of the limb attacked—yet, as a rule, the sufferers escape with the pain, which lasts only a short time. Of the non-poisonous snakes, we must mention the enormous boa-constrictor, often eighteen feet long, one of the most beautiful of all snakes.

Tastes differ, even among the Indians; for while some of them, the Cayuabas of Exaltation and the Moxas look upon turtle as the greatest delicacy, the Canitchanas, a tribe of Bolivian Indians, prefer the musky-flavoured alligator flesh to any other kind of meat. Turtles are only found in the lower course of the Amazon and the Madeira; above the waterfalls of the latter river, in the Guapori and Maori countries, they are unknown.

It happened several times near the lower Madeira, that our cooking fire was surrounded by turtles of all sizes, from the small span-long fish to the full-grown one, more than three feet in length. Prepared in every possible manner, whole and cut in pieces, as soup, roasting in their own shells, hung on a spit, and as a ragout, they steamed and bubbled one against the other, and formed a picture of culinary still life, than which nothing more characteristic can be imagined in a country where turtle soup belongs to the common things of every-day life. The best known of these turtles is the arran (*Podocnemis expansa*), described in so masterly a manner by Humboldt. Sometimes one of the canitchanas would ask permission to go out alligator hunting, a wish readily granted, for the sport always diffuses a general cheerfulness, and reinforces our stores with no despicable supplies of food. Leave being granted, the Indian without loss of time carefully fastens a strong noose of a raw hide to the end of a long pole, deftly draws his cotton shirt over his head, and enters the shallow water, advancing in a crouching posture towards the monster, and pushing the pole and noose along in front of him. The alligator, who has watched all these proceedings with apathetic calmness, only giving a sign of life now and then by a lazy flap of his powerful tail, now gazes with fixed and glassy stare at the Indian, as the latter draws nearer and nearer to him; already the fatal noose hovers at arm's length before his jaws, but he does not see it; as if spell-bound, he never removes his eyes from the daring hunter, who in another minute throws the noose over his head, and draws it up with a strong pull. The other hunters who until now have remained crouching in silence on the bank, rush to the front, and four or five dark, powerful figures, shining like polished bronze, drag the alligator, in spite of its struggles to escape, towards the shore, where a few strokes of the axe on its tail and skull soon make it harmless enough. Before the monstrous carcase is cut up, the musk bags are carefully removed, to prevent any further dispersion of the strong, penetrating flavour through the body. There are four bags, from one to two inches long, and as thick as a finger, filled with a brown, sticky liquid; they are firmly tied up, and hung in the sun to dry. It is said that the Bolivian ladies of Santa Cruz de la Sierra and Cochambamba mix this by no means agreeably scented substance with a little rose water, and notwithstanding its tendency to produce headache, use it to perfume their raven hair. The same strong-nerved senoritas prefer, as we know, a bull-fight to anything else the world can offer, and while they can dance a fandango, and roll a cigarette with inimitable grace, are scarcely capable of signing their own name.

The quieter reaches of the river are adorned with the queen of all aquatic plants, the beautiful Victoria Regia. Like an immense shield, its round leaf, measuring from four to six feet in diameter, rests upon the surface of the stream. The rim is turned up three to four inches all round, shewing in beautiful contrast to the glossy green of the upper side the crimson colouring of the under-side of the leaf. The leaf is shield-shaped; the stalk, where it springs from the centre of the leaf, is about one inch thick. Eight strong ribs or veins, often four inches thick, start from the spot where the stalk joins the leaf, branching out at right angles, and intersecting the leaf with numerous finer veinings, so that the lower surface looks as if it were covered by a large cobweb, which divided it into a great number of square partitions. This construction, framed according to the best rules of mechanics, renders the leaf extremely strong, so that, considering its thickness, we are not surprised to learn that, according to experiments which have been instituted, a single leaf can bear a load of nearly twenty-eight pounds without splitting open or sinking, and it is only natural that these great water plates of the Indians of Guiana serve as welcome resting places for numerous water birds. Both the leaf stalk and ribs are armed with elastic thorns, often nearly an inch long, but they are unable to prevent the traveller from gathering it the first time he sees the plant. The flower resembles our water lilies, and rises some inches above the water; four colossal fleshy leaves, four inches wide by seven long, enclose the bud, and serve as a protection to the numerous leaves of the corona. The blossom, when fully opened, measures about sixteen inches in diameter; when first it opens to the light, it is white, with a rose-coloured centre, but the colouring gradually deepens, until on the second day a lovely red spreads over the whole flower. A rich fragrance, like that of the orange blossom, or better still, of the magnolia, breathes from the wondrous flower. The fruit grows to the size of a child's head; its countless edible seeds lie among a spongy web-like substance. The home of the Victoria Regia embraces not only the waters of the Amazon, but the whole river system of tropical America, which roll their tributary waves toward the Atlantic. Perhaps no other plant manifests so gloriously the vitality and fulness of tropical vegetation, and Victoria Regia is not only met with in isolated examples, but hundreds of leaves and blossoms are massed together before the delighted eyes of the traveller.

Uniform as the climatic peculiarities of the Hylæa may appear, there are yet important differences in the area of distribution of certain isolated plant forms. First of all the Igapo, or inundation territory, stands forth in contrast to the Guacu forest, which lies beyond the waters, and in which the

VICTORIA REGIA.

humid heat of the equatorial climate finds its expression in the various laurel forms.

Three characteristic regions have been distinguished as being the home of the palm tribe, the monarchs of the forest: the plains, the high woods, and the marshy lowlands along the coast. As the plains are scantily distributed in the forest, the number of palms found upon them is proportionately small; the most noticeable among them being the *Iriartea setigera* and the splendid *Maximiliana regia*. But the number of palms belonging to the high woods is very great. Most of them stand alone, and lift up their waving crests among the usually still taller forest trees. D'Orbigny describes the impression produced upon him by the four storeys of the forest rising one above the other. Highest of all are the crowns of the giant forest trees 240 to 300 feet above the ground, shadowing the slender palms sixty to ninety feet high; near the right of the spectator's eye rise the delicate miniature palm trees nine to twelve feet high, and at his feet lie the thick leaf rosettes of the stemless palms. The last two groups of palms belong throughout tropical America chiefly to two great genera, *Geonoma* and *Bactris*, whose extremely numerous varieties take up the narrowest territory, and are characteristic of the humid forests of every province. Among the tall palms we notice, as being most frequently met with, the elegant Assai palm (*Euterpe edulis*), the cabbage palm (*Euterpe oleracea*), the wine-palm (*Ænocarpus*), and the *Iriartea*, admired for its wonderful aerial root formation.

Palm groves as large as the boundless forest of cocoa palms on the coast near Pernambuco, or the palmato forests (cabbage palm), in the provinces of Minas Geraes, San Paulo, and Parana, are not, it is true, found by the central and upper course of the Amazon, but groups of many thousand palm trees are frequently to be seen; and among their stems, draped with bromelias, orchids, aroids, and other plants, the travellers like to select a place to pitch their tent, choosing by preference the *Attalea spectabilis* and *Maximiliana princeps*. Among the palms in the low-lying lands along the coast, the most deserving of notice is the cocoa palm, which only arrives at perfection in the neighbourhood of the sea; for although cocoa palms are occasionally seen in the interior of Brazil, the trees have in every instance been transplanted, and are obliged to be watered from time to time with salt water, if they are to thrive at all satisfactorily. A characteristic feature of the physiognomy of the country between the mouths of the Amazon and of the Orinoco is formed by the Mauritius palm (*Mauritia flexuosa*), which, like its kindred type, *Mauritia vinifera*, lives a social life in the marshes, and forms large forests. These palm forests exclude, as a rule, all other vegetation; the smooth column-shaped stems, nearly two feet in diameter, grow so close together, that they look like a row of palisades, while the crests are interwoven one with the other, and a strange rustling is heard when the wind passes through the leaves. As, besides this palm, the *Attalea phalerata* and the wax palm (*Copernicia cerifera*), frequently form unmixed plantations in the marshy interiors, Von Martius was able to establish the interesting fact, that in tropical America, beside the beautiful Brazilian fir (*Araucaria Brasiliensis*) in the south-east of the territory, only certain palms form forests of an unmixed tree genus, while the non-coniferous trees are only found in mixed or composite woods.

These palms, which compose whole forests, seem to form an exception to the rule that the solitary kinds have generally only a limited area of distribution, and possess representative kindred types in the various river basins. This exception is never seen so clearly in any palm as in the wax palm which is found from the province of Corrientes, through the Gran Chaco, to Bolivia, and from the province of Pernambuco and Pianhy to Matto Grosso. In the marshy forests of the coast, besides the before-mentioned Mauritius palm, we also find the smaller Mauritia aculeata, with its thorny stem, the gigantic *Raphia*, the *Manicaria saccifera*, of which the leaves, with their nervous, feathery structure, are only serrated round the edge, and being otherwise undivided, resemble a gigantic banana leaf. And lastly, both here and on the shores of the inland seas and ponds, a great number of prickly *Bactris* varieties. The latter compose the formidable thickets known as *Mondorzos*, which, by their countless hard thorns of all lengths, make the woods as inaccessible as the venomous snakes and alligators found within them render them dangerous.

The whole region is rich in useful plants. For building and other purposes, palisander wood (*Palo santo*), and the so-called cedar wood, of which cigar boxes are made (*Cedrela Brasiliensis*), are universally known; but many other valuable and, botanically speaking, little known woods still wait to be felled and brought into the market. Far more important than the different kinds of wood, and than palms or orchids, whose beauties do not exist for the eyes of the inhabitants, are the cacao (*Theombroma cacao*), and the caoutchouc tree (*Siphonia elastica*), products of the primeval forests, which will be of the greatest significance for the future development of the whole country.

The caoutchouc tree grows to a height of sixty feet, and the trunk measures about three feet in diameter. It only thrives when the annual inundations keep its roots for at least four feet under water, so that the inundation territory (Igapo) is its best, if not its exclusive, home. The valuable juice of the plant, which looks like rich cow's milk, is solidified by a peculiar process of fumigation, and is well known to commerce as caoutchouc. The milky juice flows from the trunk of the tree when the soft lining of the outer bark has been pierced, and a tree so tapped yields no more sap until the third year following.

Caoutchouc Tree (*Siphonia elastica*).

The cacao tree grows nearly thirty-six feet high, and bears large lancet-shaped, downward-hanging leaves. On the trunk and boughs, even on the exposed roots, though rarely on the younger branches, grow clusters of rose-coloured blossoms, only a few of which develope into the span-long cucumber-like fruit. The colour of the latter is yellow, orange, or reddish, and its five sections are filled with a rather sweet, sticky, white pap, in which are concealed, stored up in five long rows, and held together by the "pap" and the split partition walls of the original sections, the numerous seeds, or cacao berries, which form the basis of chocolate. The trees often form absolute thickets, which are all the more impenetrable because many branches bend down again to the ground and take root. The seeds of the wild plant are not much valued, and as they are mixed with the seeds of the cultivated cacao which are prepared for exportation merely by drying them in the sun, Brazilian cocoa, which is said to be very good, has lost much of its well-deserved reputation; but notwithstanding this prejudice, a hundred thousand pounds worth is exported yearly. The fruits are gathered twice in the year, and a single tree yields about two to four pounds of berries. The cacao tree is

URANIA SPECIOSA.

only cultivated on any large scale in a few parts of Hylæa, and even less labour is bestowed on it in the rich districts of Guayaquil, whence Germany imports its principal supplies; for there most of the plantations are said to date from the time of the Conquista, or Spanish invasion. Not indeed that the tree can bid defiance to the lapse of centuries, but it puts forth fresh shoots from its root, and so relieves the lazy inhabitants of the trouble of cultivation. Besides the cacao tree, the forest does not neglect to provide us with fragrant vanilla to perfume and flavour our chocolate.

Gutta-percha, cocoa, and vanilla are by no means the only treasures stored away to reward the trouble of the collector in the boundless forest region of the Amazon. Nearly £375,000 worth of Para nuts alone, the fruit of the *Bertholletia excelsa*, is exported at the present day. The amount of ruku, the red dye of the *Bixa orellana*, together with the copaiva balsam from the *Copaifera Jacquini* and other trees, represents a value of nearly £12,500, and although these sums appear comparatively small, we ought not to forget that perhaps a hundredfold more of the above-named fruits perish in the forests, and that there exist many more valuable seeds and fruits of no value to the Indians, only waiting for the diligent botanist and the experienced merchant to be brought forward as valuable articles of exportation. Numberless costly gums for the manufacture of varnish, dye-woods of the most brilliant hues, fibrous plants suitable for the finest textile fabrics, and cords for the strongest cables,—these, together with the plants before mentioned, and powerful medicinal drugs, compose some of the riches of the insufficiently explored forests. And how much might be added by diligent and intelligent culture to the lavish gifts of nature! For instance, indigo thrives so well that it may be hoped that this costly dye, which is at present only grown for household consumption, will soon become a regular article of trade to be purchased at a low price.

The natives, however, understand also how to use the treasures of nature for their own purposes.

"Most of the oarsmen, not occupied in cooking, spent their leisure time in making themselves new hempen shirts, the material for which is found in abundance near the halting place. The forest re-echoes at once with the stroke of the axe and the crash of the falling trees (*Curatari legalis*), the Indian *turury;* and before the call to breakfast is heard, the men are seen dragging along the bundles of glossy bast, each piece being about twenty-eight inches wide, twelve feet long, and one inch thick, to turn them into cloth. The machinery used in the process is of the simplest character, and consists of a notched hammer of heavy wood, the so-called *maceta*, and a round piece of wood placed underneath it. By the strokes of the hammer, the fibres of the maceta are loosened in such a manner that not only their undulating graining is brought out, but the thin plate of wood, hard at first, becomes soft and pliant, and stretches to twice its original width. After this the piece is washed to remove the sap, wrung out, and hung up to dry. It looks now like a coarse woollen material of a glossy whitish yellow or yellow-brown tint, and shews two principal markings of undulating fibres, which, without crossing, are connected into a whole by countless tiny fibres, while the notches of the maceta impart to it the appearance of a fine damask. No more quickly made garments, and none more adapted for working clothes in this tropical climate, can be imagined than these cascaras of the Bolivian Indians. The cut of the garment emulates the classic character of the material; it is simply a piece of bast, perhaps nine feet long, with a hole cut in the centre for the head to pass through, and the two sides sewn up as high as the waist. A belt of cotton, twisted cord, or a handy liana, completes the original costume, to which the Panama palm contributes the hat."—*Keller Leuringer.*

If we turn to the medicinal plants, the names of ipecacuanha, sarsaparilla, copaiva balsam, and simaruba (*Simaruba officinalis*), will suffice to shew the wealth, nay, the unique character, of these forests; but how many priceless herbs may still unfold their leaves and blossoms, without their hidden properties and mysterious powers being known even to the Indians! And we may mention here the two sorts of poison discovered by the Indians, the guarana and the arrow poison.

Who has not heard of the curare or urari, that rapid poison used by the Indian tribes to poison their arrow tips, and which in the hands of skilled physiologists and physicians has not only led to interesting discoveries connected with the nervous system, but has also become a valuable medicine? The sensational stories told by earlier travellers of the preparation of this deadly poison have long since been condemned. It is prepared by boiling over a slow fire the juice extracted from the bruised stems and leaves of several kinds of strychnos and dogbane (*Apocyneæ*), mixed with tobacco juice and Spanish pepper, and with a thick milky fluid, probably obtained from the *Euphorbia esula*, or wolf's milk, and thickened until it becomes a solid mass. This preparation is not entrusted to women devoting themselves to a terrible death; but as it is attended with no danger whatever, it is probably undertaken by the men themselves. There are, moreover, at least eight or ten different kinds of poison, of similar but not identical composition and manufacture, among which the urari of the Makusi Indians and the curare of Venezuela and New Granada are considered to be the strongest.

The dark-brown substance resembling pitch is kept in small clay pots, and is used not only to smear the tips of the long reed arrows made of hard palm wood, and the small needle-like arrows shot from colossal blow-pipes, but also for the points of lances. As soon as the slightest quantity of poison enters the blood, the limbs become powerless one by one, as if in overpowering sleep, and death ensues in a few minutes, the brain remaining clear to the last. The Indians use a very attenuated preparation of urari to shoot birds and monkeys which they intend to tame. The lethargy induced by the poison is afterwards counteracted by strong doses of salt or sugar, and it is even said that the after-effects of the poison are sufficient to remove much of the original wild nature of the animals. It is a singular fact that none of the Indian tribes dwelling on the right bank of the Amazon possess any knowledge of the preparation of the urari, although the plants which are its chief ingredients are found there in equal abundance as upon the left bank, where many tribes, differing in language, make use of the terrible weapon in the same manner. By what chance the Indians were led to discover the means of preparing the poison is difficult to discover, the more difficult because the deadly properties of the plant are by no means strongly perceptible before the juices have been concentrated by the method of preparation. However that may be, the discovery was a very important one for the chase, the principal pursuit by which the tribes live, as by its help no animal, however slightly wounded, can escape them; and when once their attention was aroused to the existence of the poison, they would naturally try to preserve their discovery, and to extend and improve the method of its application.

Guarana is obtained from the fruits of the *Paullinia sorbilis*, a small feathery-leaved tree. It is brought into the markets in cylindrical pieces from eight to twelve inches long, and is a very hard, chocolate-coloured substance, bitter to the taste, and almost inodorous, the half-crushed almond-like seeds being generally visible within it. The harder and more even it is, the better is the quality. To make it palatable, it is powdered as finely as possible with a rasp or the hard bony teeth of the piraruku (*Sudis Gigas*), the monarch of the Amazon, mixed with a little sugar, and drunk cold in the proportion of a teaspoonful of guarana to a glass of water. The taste of this beverage is by no means unpleasant, and is not unlike almonds, but it is too slight to account sufficiently for the passionate preference shewn for it by the inhabitants of certain parts of South America. Mixed with warm water, it is looked upon as a remedy in slight attacks of intermittent fever. But that which makes it so indispensable to the guarana drinker is probably the *guaranin* contained in it; a stimulant acting upon the nerves, and similar in its properties to caffein. The canoes, lightly freighted with deer and puma skins, which descend the Arinos and Tapajoz from Matto Grosso, notwithstanding the numerous rapids and cataracts of the latter river, take on board at Santarem a complete cargo of guarana as a valuable return freight; and the heavy boats ascending the Madeira to Bolivia also carry a large quantity, for there are many people both in Cuyaba and in Santa Cruz de la Sierra who absolutely cannot live without guarana, for which they have to pay twenty-five shillings a pound, and who would rather fast from food than deprive themselves of their favourite beverage. Among the Mestizos of the Amazon, on the other hand, where guarana is prepared in large quantities by the half-civilised tribes of the Mauhés and Mandurukus, and where it may be bought for about two shillings and fourpence a pound, the consumption is not very great, and tea or chocolate is the favourite drink of the people.

The real objects of culture are of comparatively small importance beside the treasures of the forest; and we need only mention maize, which is cultivated in different methods by the different Indian tribes.

The Region of Trans-Equatorial Brazil.—South Brazil and Bolivia.

The vegetation of South Brazil is determined by its vertical configuration. Granite mountain chains extend along the coast from the south-eastern limits of the territory to the mouth of Rio Francisco. Westward, from the Parana and Rio Francisco to their watersheds, strata of clay slate form the soil of a lower mountain district which descends in the west to the valleys of the Paraguay and the Madeira. Virgin forests clothe the coast-lands and the depression between the last-named rivers and the Andes; the rest of the country is occupied by savannahs which are called here campos.

It is easy to see how the formation of the surface must necessarily act upon that of the vegetal covering. The whole of Brazil, as far as it lies beyond the equator, stands under the influence of the south-east trade-wind, which, coming from the Atlantic Ocean, blows towards Hylæa and the Andes. But as the mountain chains of the coast oppose their lofty peaks to the damp wind, they withdraw from it much of its moisture; and it is this constant accession of water which, together with the great heat, produces forests of such extent and magnificence, whose tropical splendour is unequalled in any other part of the world, unless it may be in the Indian archipelago.

And yet, as the humid warmth of the climate relaxes the receptive powers of the mind, and as the trouble of penetrating into the overgrown thickets, and collecting for oneself the flowers and fruits from the various trees and lianas, requires such an effort that even in the most frequented districts the knowledge of all the minute details remains imperfect, so does the first feeling of amazement at the powers of vegetal formation soon yield to a certain weariness, which is increased by the recurrence of similar impressions. The details appear wonderful, but the whole effect is unsatisfactory. This fulness of mutually supporting organisms lacks air and light; the picture is framed by no horizon; an oppressively hot atmosphere, filled with the scent of mould, weighs down the heart, which rises amid freer air and wider distances, and feels relieved by the unlimited.

Generally speaking, the vegetal formations from the heights of the mountains to the mangrove forests by the sea-shore are the same as in other hot and humid climates of tropical America. But in the higher latitudes the impression of luxuriance and diversity of the plant life, in contrast to the fulness of the foliage of the Hylæa, is heightened by the more frequent recurrence of large and brightly coloured blossoms. Among the show of plants are several rue-worts, and *mutisiaceæ*, composite plants with labiated blossoms peculiar to South America.

The more open slopes of the Organ Mountains (and it is doubtless the same in other places) are more richly endowed both in variety of tree forms and in the number of epiphytæ, but the scale of fully developed growth is not so grand as in the rich soil of the low river valleys, which are filled with giant trees surrounded to a great distance by smaller stems, and forming such a dense roof of leaves, that every ray of light is kept back from the ground. Among the most striking tree forms are a few myrtle growths and the palm tree (*Astrocaryum ayri*). Several trees found in the mountain forests of Rio are absent from these dark shades; among them the tree-ferns, the bamboos, which in the clearings of the high woods grow to the height of forty-five feet, the cabbage palm, found under the shadow of the tall bamboo, and the *Cecropiæ*, distinguished by their large white leaves.

The plant forms of the campos, from the neighbourhood of the equator to beyond the tropical circle, are connected through all their diversity of production by gradual transitions. There are, however, according to Von Martius, three distinct sections; the northern plain (3 to 15° lat., in the valley of San Francisco to 20°), the central table-land (15 to 23°), and the southern districts (23 to 30° S. lat.) In the more northern campos, as in the cis-equatorial llanos, the savannah grasses prevail (millet, reed-grass, and *Restiaceæ*), with their unenclosed turf, from which rise solitary column-like cacti. The silk-cotton tree (*Chorisia ventricosa*) is also a common sight in the savannahs, the trunk swelling in the centre into a barrel-shaped protuberance. With the rise of the ground upon the table-land the number of bright-coloured shrubs, especially of gentians and melastomaceæ, increases. Vellosiæ are added to the ranks of liliaceous plants, and the loftier cacti are replaced by the small melon cactus. Upon the table-land of Minas Geraes, which is intersected by many streams, and rises in many higher mounds and plains, the diversity of vegetation reaches its highest manifestation. The district is described as a richly adorned and boundless flower-garden, where every kind of plant is new, and each outdoes the other in beauty and rarity. The large unmixed woods of Araucariæ (*A. Brasiliensis*), the pinheiros, are peculiar to the savannahs of the South.

The inhabitants distinguish the separate formations of the flora by different names. The title of true campo (*Campo vero*) is only applied by them to the grassy plain which, with its rich beauty of flowers, extends over measureless levels; the *Campo serrado* is the plain bestrewn with scattered shrubs; the *Campo aberto* is marked by liliaceous trees; a connected growth of low shrubs, which do not hide the horizon from the traveller's sight, is the sign of the *Carrasco*, the *Carrasceino* growing from twenty to thirty feet high. The campo woods are sometimes called *Capoes*, or wooded islands, and sometimes *Catingas*, the latter forming the most striking appearance of Brazilian scenery. During the dry season they are almost leafless; but if, as often happens, the rainy season is withheld for a time, not a vestige of green is seen upon the ground as long as the drought lasts, except the numerous column cactus growths and the fig cactus (*Opuntia*), both represented here in every variety, and the numbers of green parasites and epiphytæ which remain clinging round the leafless stems. When woods of this nature are cleared, the ground is found to be perfectly exhausted; large tracts of land on the Minas Geraes, once covered with forests, are now sterile, and scarcely available even for pasturage, being overgrown partly with a worthless kind of fern, and partly with a clammy, ineradicable grass (*Melinis*), which is certainly eaten by cattle, but which is said to be injurious to them. The capoes are evergreen woods of limited extent. Viewed from outside, they are like wooded hills, for the higher trees in the centre are surrounded in terrace-like gradations by lower growths. The interior is occupied chiefly by the laurel tribe, represented by a number of varieties, together with the tamarind and countless epiphytæ.

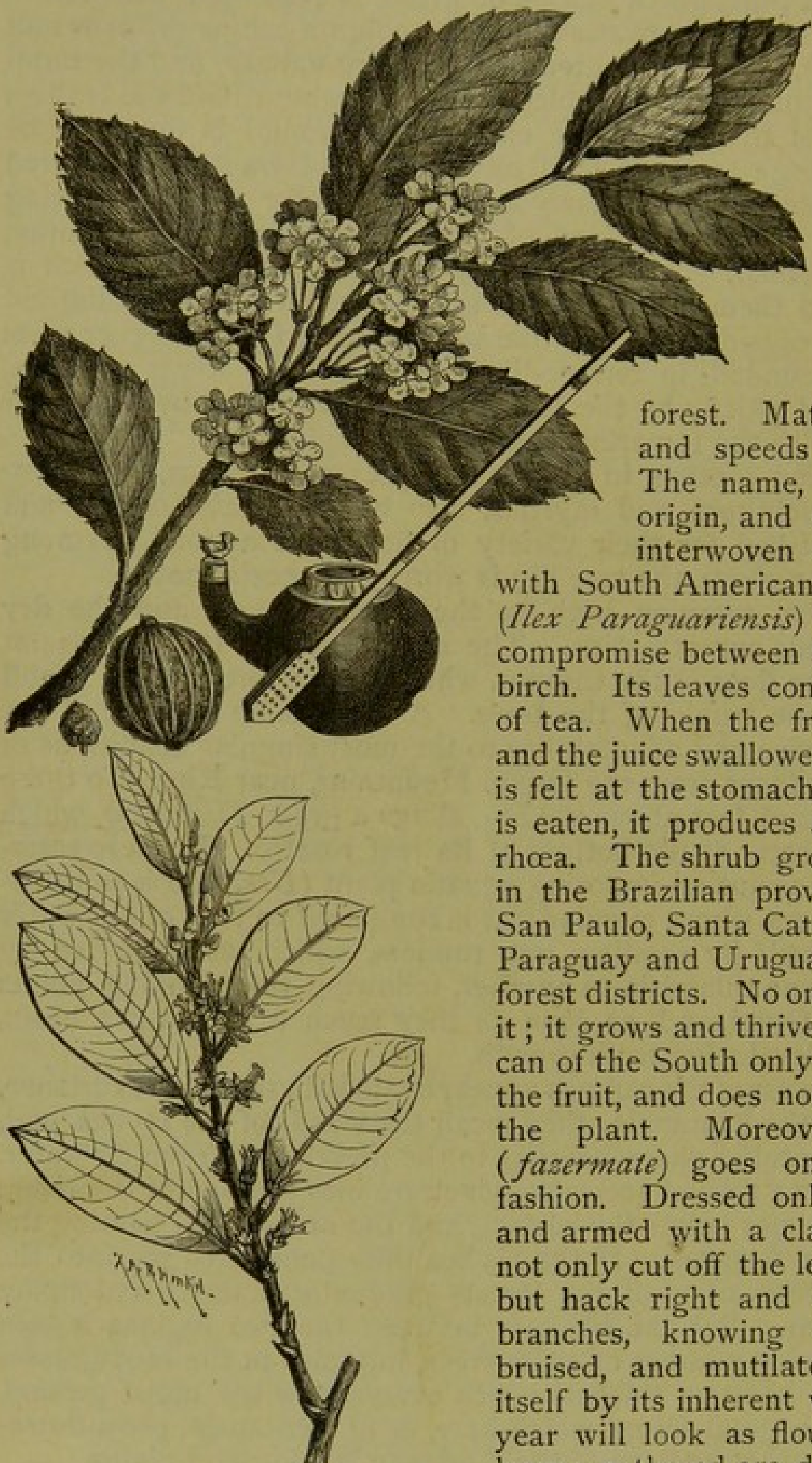
The shrub formation consists, in certain localities, of mimosas, or is composed of oleanders, buckthorn, and myrtles, also by the *Melastomaceæ* and *Malpighiaceæ*, distinguished for their variety of flower formations. Among the plants of the *Campo aberto*, the tree lily is worthy of special notice.

The bromelia tribe, common both to the humid forests and the dry savannahs, also demands our attention. The sedgy grass of the ananas not unfrequently clothes the floor of the campos, while in the forests it is found chiefly growing from the trunks of the trees. A remarkable instance of the greatest economy of space and adaptability to the most singular conditions of life is reported by Gardener from the Organ Mountains, near Rio. To these rocks, some four thousand feet above the sea, clings a great *Tillandsia*, which collects a quantity of water at the bottom of its leaf rosette. In these reservoirs, and there alone, swims an imposing aquatic plant (*Utricularia nelumbifolia*), with purple flowers, whose circular leaf is compared to that of our water lily. It propagates itself by sending out runners, which, as if guided by instinct, extend from one tillandsia to another, following the standing points which the flower has found, and, as soon as they reach a new water basin, plunging into it, and developing fresh growth.

The forests in the west of the campos appear again with tropical luxuriance, and form the zones of the Pantanals; they recall the woods of the Hylæa, and, like them, owe their peculiar characteristics to the presence of running water. As in the Igapo, the tree thicket seems to penetrate into the bed of the river; the stems bending at times below the surface, and the muddy soil bearing the reed-grass seen by the Amazon. If the Hylæa thus penetrates far into the south of Brazil, the composition of the forests gradually changes, and many valuable trees disappear. But the likeness between the two regions is seen not only in the increasing number of palm trees, but also in the reed-grasses and the impenetrable bamboo thickets which overshadow the moist ground, and the tree-ferns, all vegetal forms, which here, as in Venezuela, press downward from the neighbouring valleys of the Andes to the lowland plains.

A remarkable plant found in the virgin forests is ipecacuanha, which, when it had become so scarce in the coast districts as to be no longer sufficient to meet the demand, was opportunely discovered in the Pantanals of Matto Grosso in such profusion that there is now much less ground for the fear that this indispensable medicinal plant may one day be lost to us. Of the remaining characteristic plants of this territory, which possesses about ten thousand native species, we will mention only coca and maté.

Maté is the household word on every Spanish tongue and in South America. It is the cry of half the Portuguese inhabitants, and the universal watchword from Rio Grande in South Brazil, throughout the whole of South America. Maté is the first word of the day at home, on the campo, or in the forest. Maté "greets the coming and speeds the parting guests." The name, which is of Indian origin, and simply means herb, is interwoven in the closest manner with South American life. The maté shrub (*Ilex Paraguariensis*) is, by its formation, a compromise between the coffee tree and the birch. Its leaves contain *théine*, the essence of tea. When the fresh leaves are chewed, and the juice swallowed, an agreeable warmth is felt at the stomach; but if the leaf itself is eaten, it produces a slight attack of diarrhœa. The shrub grows in such abundance in the Brazilian provinces of Rio Grande, San Paulo, Santa Catharina, Coritiba, and in Paraguay and Uruguay, that it forms whole forest districts. No one dreams of cultivating it; it grows and thrives at will. The American of the South only understands gathering the fruit, and does not trouble himself about the plant. Moreover, the maté-making (*fazermate*) goes on in rough-and-ready fashion. Dressed only in a pair of trousers, and armed with a clasp knife, the workmen not only cut off the leaves of slender sprays, but hack right and left among the thick branches, knowing well that the torn, bruised, and mutilated plant will recover itself by its inherent vitality, and in another year will look as flourishing as ever. The leaves gathered are dried before a slow fire, and pressed into baskets of bamboo cane or sacks of raw oxhides.



Spray of the Maté Plant with Fruit (natural size and enlarged). Teapot and Pipe through which the Tea is Drunk. Underneath, Spray of the Coca Plant.

How then is maté eaten? Indians and negroes eat the leaf straight away; when pressed, they use it as tobacco. In the south-west, maté-smoking among the coloured population takes the place of a morning cigar. From year's end to year's end in every Brazilian house stands a great earthen vessel filled with water, and a second containing cold maté. Now maté, or Brazilian tea, is familiar in our newspaper advertisements. It is announced as something brand new, but this is not the case, for maté, then called Paraguay tea (*Herva da Paraguay on de San Bartolomeo*), was drunk in Europe 200 years ago, and sold at a high price.

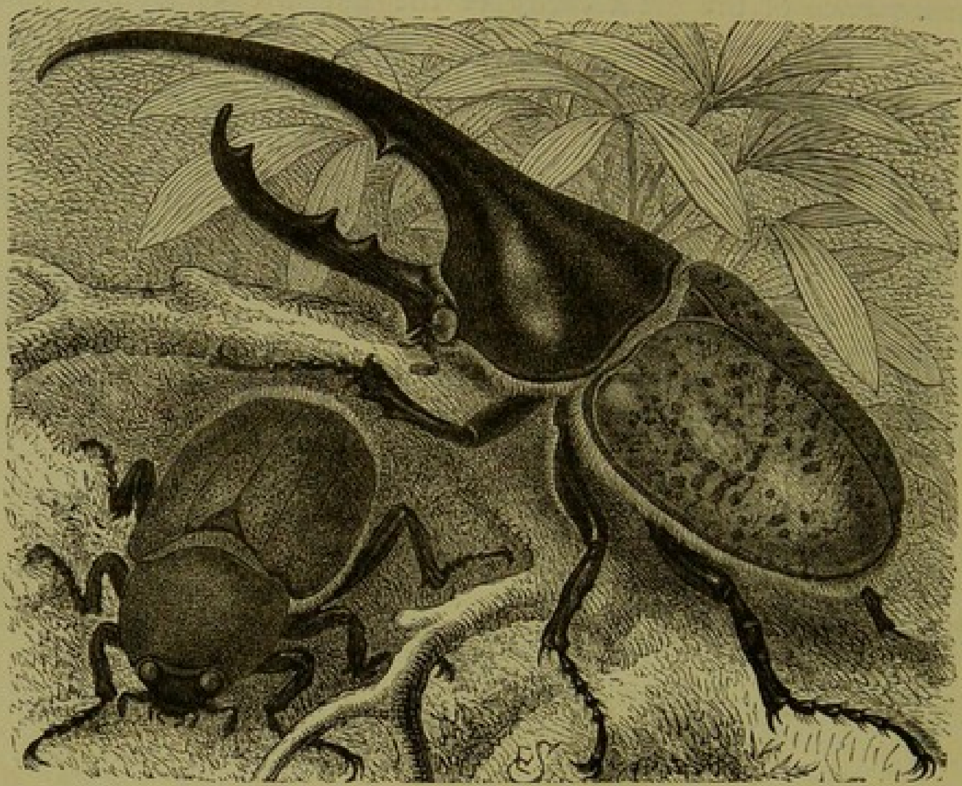
The favourite stimulant for the nerves among the Indian tribes of Bolivia is coca. The leaves of the coca tree (*Erythroxylon coca*), about an inch long, and dried in the sun, are grown in Bolivia and Peru on a large scale. When dried, they are mixed with a little fine ash and red pepper, chewed, and the juice swallowed. On the heights of the Cordillera, not only is the penetrating cold less severely felt by keeping some of the coca leaves in the mouth, but the painful contraction of the chest, which oppresses the traveller as a consequence of the great rarity of the air, is considerably relieved;

FRUIT-BEARING COCOA PLANT (*Theobroma Cacao*), WITH FLOWERS AND FRUIT.

indeed, no Quitchoan Indian would dream of crossing the snow-clad passes without a sufficient store of coca leaves. It is certain that these men, who cross the Andes by almost impassable tracks, heavily laden with baggage, and without any strengthening food but coca, arouse the admiration of every traveller by their wonderful feats of great endurance. It is scarcely necessary to say that coca, like all narcotic stimulants, by exerting the most delicate fibres of the nervous system to greater momentary activity, tends, if used for any length of time, to wear out the frame, and render it prematurely incapable of work. When drunk as tea, coca tastes aromatic, with a faint flavour of camomile.

The Indians of Peru have a singular habit of measuring distances by so many mouthfuls of coca (*Cocadas*). To understand this we must remember that the stimulating effect produced by the chewing of a few leaves continues for a definite period, and if the coca globule (*Acullico*) held in the mouth is not refreshed by the addition of new leaves, its effects pass off, and a reaction of physical weakness sets in. The time during which the stimulus lasts, or, to speak more strictly, the distance which can be traversed in that time, just as among ourselves we may reckon by the number of cigars smoked, expresses what the Indians of the province of Pataz understand by the name of *cocada*. "As a result of the observations made during my journey," says Bastion, "it may be concluded that the excitement begins after the coca has been held in the mouth for about eight to ten minutes, and that if no fresh leaves are added, it will last for thirty-five to forty minutes."

Little need be said of cultivated plants. Coffee, sugar, cotton, and tobacco, together with the treasures of the great forests, dye-woods, cocoa, and drugs, form the principal exports of Brazil. To these we must add from the animal kingdom horns and hides. The Jerusalem artichoke (*Helianthus*



HERCULES BEETLE (*Dynastes Hercules*), MALE AND FEMALE. Two-thirds of natural size.

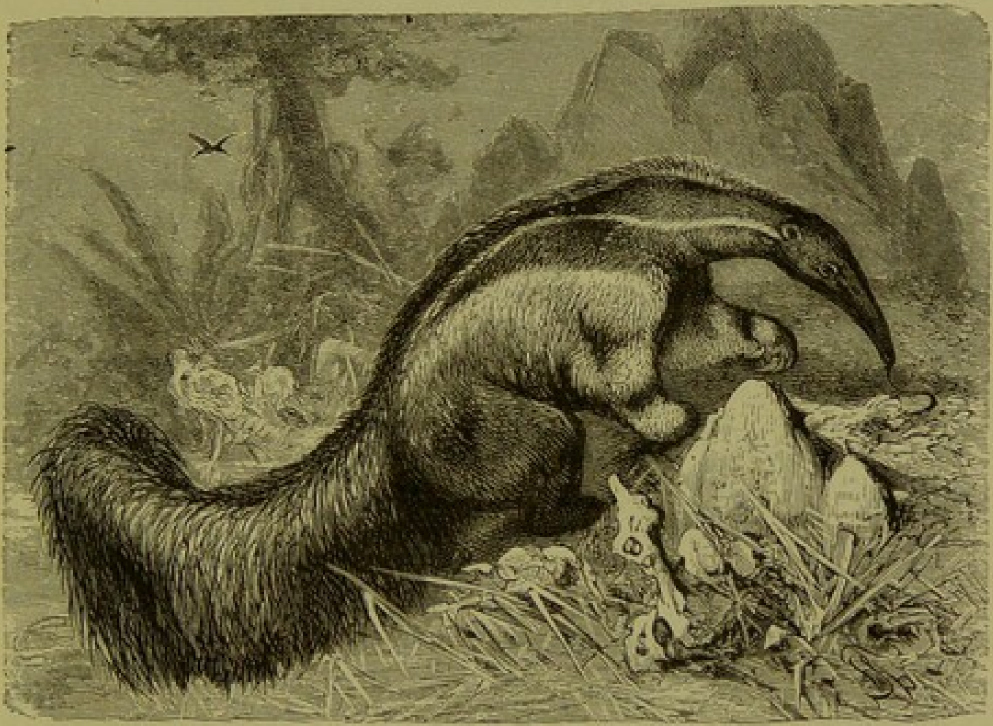
tuberosus), which was introduced thence into Europe, is used in many ways by the people of the country.

The fauna of this region is not extensive or varied, and the following is all that Avé Lallemant is able to tell us of a ride through the campos :—

"The traveller rides at will over the wide grassy plain ; but he soon finds that it is as well to look closely after his horse. Hidden beneath the grass in every part of the campo lie the holes which serve as the entrances to the burrows of countless armadillos ; everywhere rise the ant-hills, little mounds as hard as iron ; everywhere one has the risk of being thrown. From the closer tufts of grass, or from beneath some bromelia, a partridge rises whirring close to the rider. The guero-guero, with his spur-tipped pinions, shrieks incessantly from the back of some grazing cow. A few hawks and kites circle overhead in restless flight, while here and there a little screech owl is seen standing erect and motionless upon the summit of an ant-hill. No house, no human creature, is in sight, nothing but scattered herds and shy horses, and even these soon in small numbers. A troop of young deer trotted quietly before us through the grass, just as if they had never seen a man who could work them any mischief. Immediately afterwards a brace of pampas deer (*Cervus cam-*

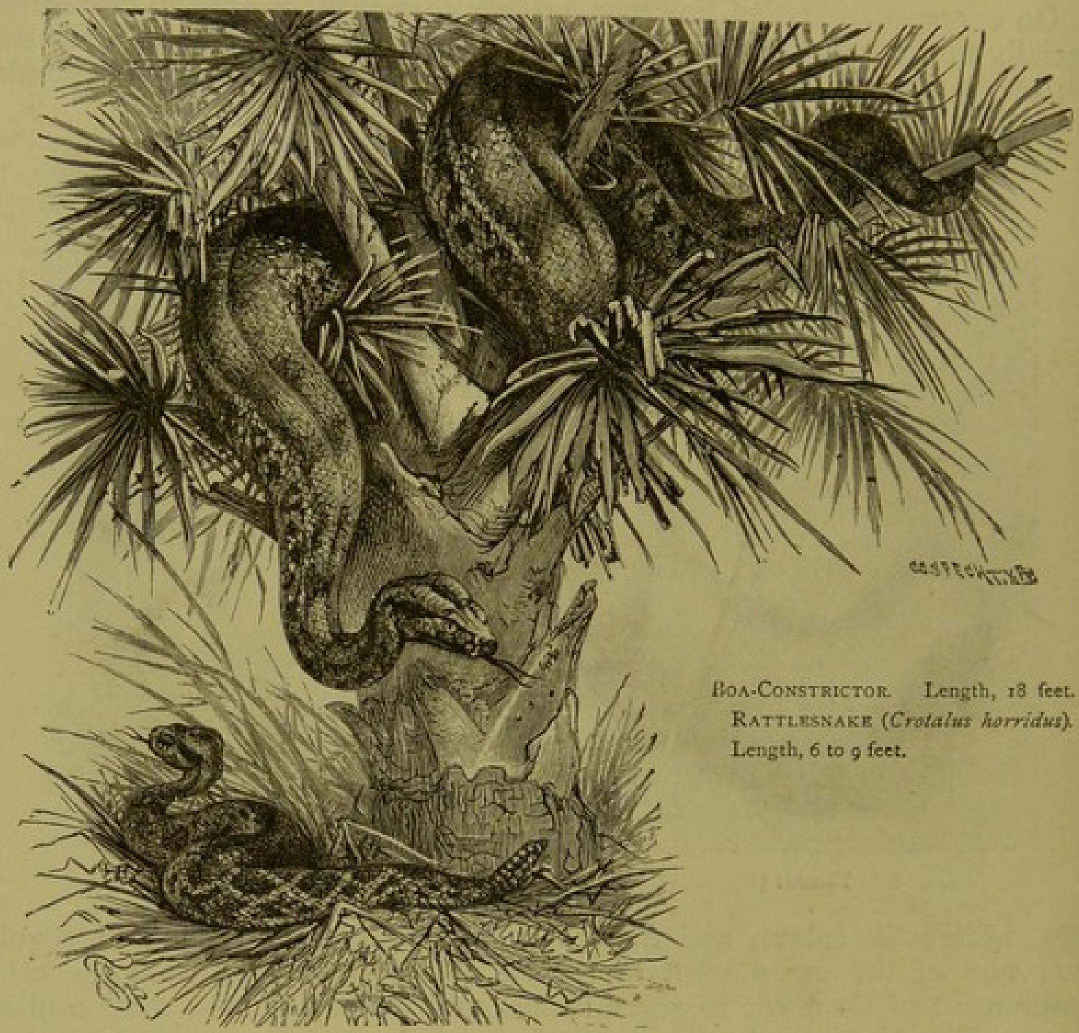
pestris) sped by along a hillside, with free and noble motion, the slender creatures seeming scarcely to touch the grass blades with their flying feet. And now there trots by, sometimes running, sometimes feeding, the pampas ostrich (Nandu, *Rhea Americana*), while partridges rise whizzing into the air from the grassy tufts on every side, and numerous birds of prey hover round the hills on the look-out for prey. So much, but no more, did the hot noon-tide hour bring before our notice. Our horses, and after a while we ourselves, were plagued by numberless horse-flies, some beautiful glossy creatures, almost white, with green eyes. A pretty *mantis* was also seen, as long as a *phasma*, with short straw-coloured wings, and enormously long neck. It struck out viciously with its spurs till I let it fly."

On closer examination, however, a richer animal life is after all discovered, especially in the insect world. This is the home of the greatest of all butterflies; of the owl *Agrippina*, a bird measuring about ten inches with expanded



YURUMI (*Myrmecophaga jubata*). Length, including tail, 7 feet.

wings, whitish in colour, and flecked with dark spots arranged in regular rows; and of the magnificent morphidæ, all of which exceeded the usual measurement of from six to seven inches, and shone with the most brilliant colours. The Hercules beetle, as we know from our European collections, cannot be very scarce, but the great bird-spider, seven inches long (*Mygale*) which kills and eats the smaller birds, is also found under stones and bushes. The *phasmæ*, although they are a span long, are often overlooked, because they are more like dry boughs than living animals. Among the mammals of the campos we must not forget the wolf, the jackal-fox (*Canis azaræ*), ant-eater (*Yurumi tamandua*, or *Myrmecophaga jubata*), and the aperea (*Cavia apera*), a little creature which provisionally has the strongest claim to be the ancestral type of the *Cavia cobaya*, or guinea-pig. Among birds, the *Dicolophus cristatus*, and in the marshy districts the *Parra jacana*, a bird with wings armed with spurs. Snakes and serpents are represented by the boa-constrictor and the rattlesnake (*Crotalus horridus*). In the northern parts of Brazil and in Guiana is found the mysterious *Cercoleptes caudivolvulus*, a bear, which has for so long perplexed our naturalists, and the innocent calumniated vampire (*Phyllostoma spectrum*), a bat measuring with extended wings twenty-eight inches, which hotly pursues insects by night, and also feeds on fruit. And although the blood-sucker (*Desmodes rufus*) does occasionally draw blood, yet the stories told of its attacks need investigation, and in any case its reputation is worse than it deserves. In the rivers of Brazil is found a fish three feet long (*Lepidosiren paradoxa*), which breathes through gills and lungs, and of which only two kindred types have as yet



BOA-CONSTRICTOR. Length, 18 feet.
RATTLESNAKE (*Crotalus horridus*).
Length, 6 to 9 feet.

been discovered; namely, the *Protopterus annecteus* of southern and central Africa, and the *Barramudi* (*Ceratodus Forsteri*).

SOUTH AMERICA BEYOND THE TROPICAL CIRCLE.

The traveller who leaves tropical America to penetrate southwards to the point of the continent finds that the temperature decreases in a most unusual degree. The abrupt transition to cold climates is manifested most clearly in the sudden fall of the snow-line upon the Chilian Andes. Near Aconcagua (33° S. lat.) the snow-line lies about ten thousand feet above the sea level, that is, only 940 feet lower than on the equator; but six degrees farther south it is found to have sunk as low as five thousand feet, or, in other words, as low as the snow-line of Norway, in districts which are nearer to the pole by

1,800 miles. But it is only in America that we find this almost immediate transition from an Andalusian to a northern climate, and the consequent limits for the separation of the natural floras, because this is the only continent which extends southward to those latitudes which are exposed to the chilling influences of the Antarctic Ocean; and it is moreover so contracted as it nears its southern extremity, that its climate would seem to depend wholly upon the ocean which flows round the whole globe; although even here we find great differences of climate, according to the different formation of the soil.

Beginning in the east, we may briefly class together the whole area situated to the east of Paraguay and Parana; namely, that part of Brazil which extends into the temperate zone, the Argentine republics, Paraguay, Entre Rios, and Uruguay. Paraguay is adorned by high, luxuriant woodlands, the value of which is increased by the number of maté shrubs found

VAMPIRE (*Phyllostoma spectrum*). One-fourth natural size.

growing among the other trees. But there is said to be also a rich field for every other object of culture found in hot climates. It is much to be wished, both in the interest of science and of commerce, that an expedition of scientific and practical men should be sent to travel through these regions, which, according to all reports received, may confidently expect a grand future, when the tide of colonisation is again turned towards them. It is not, however, possible to study a country which treats every one who crosses its frontier as a prisoner; and the long years of captivity endured by Boupland, Humboldt's famous travelling companion, were sufficient to warn and deter subsequent explorers; for he was first imprisoned in a fortress as a regimental surgeon, and afterwards employed in the remotest districts as a road surveyor.

Although much more accessible, the district between the rivers, that is

Entre Rios and Corrientes, is almost as little known with respect to the character of its vegetation. On the other hand, we are well acquainted with the wealth and fertility of those districts, which, if only they are allowed to remain in peace, may become some of the most important and strongest provinces of the Republic. It is established beyond all doubt, that they are exceptionally adapted for agriculture, and for colonising, and that they will become the granaries of the whole country. And yet, although we know approximately what objects of agriculture can be supplied by these Argentine provinces, we are still extremely ignorant as to the native vegetation. Generally speaking, it may be said that the difference between them and the pampa, of which we shall speak later on, is that woody growths, so far from being poorly represented, are found in great abundance. Even on the rich grassy plains of the gently undulating land, bushes and small thickets of shrubs are scattered on all sides. River banks and islands are fringed by bushes ; and even woods are not entirely wanting. The interior has its large and well-known forest of *Montiel,* well known, that is, by name ; and many of the islands in the river are said to be wooded ; while there is no lack of woodlands by the river-side, chiefly composed of the yatai, and some other (probably four) kinds of palms. The yatai is the most general of all the palms in this place, and extends without interruption for miles together, forming large woods, the hard, feathery, silver-grey leaves arresting the eyes of the stranger, just as the sough of the wind through their crests attracts his ear. Moreover the grassy carpet, at least in the restricted space which the naturalist Lorentz was able to observe, is widely different from the pampa ; it is a short, close turf, chiefly consisting of *Paspalum notatum,* and having only widely distributed growths in common with the meadows of the east. The large remnant of the pampa territory traced upon our maps is divided by Lorentz into five botanical formations, two northern, two central, and a southern. The two northern formations are bounded in the south by a line which connects La Plata with the north-eastern corner of the *Chilian* territory ; the western or subtropical of them being twice as wide as the eastern, that of the Chaco. The central formations comprising the Atlantic, or true pampas, and on the western side the forest land, or *Formacion del Monte,* are of almost equal width, and extend southward as far as the Rio Colorado, which is also the northern boundary of the Patagonian formation. Of these districts the pampa and the monte will probably furnish for a time the principal meat supplies of the Argentine territory, while the subtropical park-land of the gardens, the subtropical and Chaco forests, are the timber depôts of the country, and Patagonia is for the present of no importance whatever. The subtropical formation is rich in scenes of fertility and luxuriance, which enchant the traveller all the more because he is almost always compelled to reach them through wide stretches of country, verging on the type of desert land, and occupying many toilsome days in the transit. It is determined by the lofty rocks of the Cordilleras, and their outrunning heights which intercept the vapour-laden winds coming in from the Atlantic, and deprive them of their moisture.

The mountain pasture lands of the Cordilleras are not clothed by a smooth, close carpet of turf, but by isolated bunches or tufts of tall and generally small-leaved grasses. As early as September, the first month of the spring brings with it wealth of flowers, principally bulbous roots, lilies, amaryllidæ, and sword lilies. The summer unfolds a gay profusion of blooms, among which showy representatives of composites (*Cosmos, Bidens*) prevail; and with autumn come the gentians, slipper-wort, calceolarias, mimulus, and gerardias, the latter indeed being the characteristic plants of the region. Wherever the high valleys open out, or the slopes become more level, a dwarf vegetation appears with the creeping *Alchemilla minima*. Descending the mountains and leaving the alpine meadows, we enter the Queñoa region, a zone of which the characteristic tree is the rosaceous queñoa (*Polylepis racemosa*). Next to this, between 6,600, and 3,750 feet above the sea, lies the Aliso region, a dense, shadowy wood, consisting almost exclusively, on the steeper mountain slopes, and in the deeper ravines, of *Alnus ferruginea var. Aliso*, closely resembling our own alder. Sometimes, though rarely, the sauco (*Sambucus Peruviana*) and shrubs of stately flowering eupatorias and eskallonias are found growing among the aliso trees. Grasses and herbs (gentian, sorrel, baldrian, and thalictrum) are rare, while ferns, selaginelles, lycopodeas, are numerous, and the trees are overgrown with orchids, tillandsia, ferns, mosses, and many beautiful lichens. Lower down, and more on the northern slopes of the Cordilleras, lies the region of the Pino (*Podocarpus angustifolia*). Finally, at the height of 3,600 feet, we reach the subtropical high woods. They are composed of a variety of lofty and nobly formed trees, whose high and leafy crowns cast a refreshing shade, without however excluding the light too completely to allow the growth of a rich underwood of low trees or shrubs which partially fill up the space left between the lofty trunks. Where the shadow falls deeper, the soil is chiefly occupied by tall ferns, and even the trees are closely overgrown with a large number of epiphytæ and, though more rarely, of parasites which issue from the most diverse plant families, orchid and anana growths, pepper plants, cacti, ferns, mosses, and lichens. Not infrequently also we find plants which usually prefer the ground, rooted in the decaying parts of the tree, or in the soil which accumulates in the junction of two branches; so that bushes, or even small trees, are seen flourishing upon totally different ones. Immense lianas cling round the trunks, and wave between them, hanging down like ropes from the trees, with curious twisted stems, often sending downward their aerial roots, and in the spring clothing the trees with the richest blossoms.

The most common and the finest tree is the tipa (*Machærium fertile*), covered in spring by countless yellow butterfly-shaped blossoms, to be followed later on by pinnated fruit: besides this we find a laurel (*Nectandra porphyria*), a nut tree (*Juglans nigra*), the so-called cedar (*Cedrila Braziliensis*), whose soft fragrant wood is an article of exportation, but is being collected so recklessly, that it is now idle to look for a cedar on the frequented roads, and old trees are looked upon as the greatest rarities. Another principal tree of these forests are the different species of acacia (*Cebil blanco* and *colorado, Horco cebil*), with strong white stems. Eugenias and myrsinias form the transition to the lower tropical forests with the *palo borracho; Chorisia insignis*, one of the most singular tree formations, with a turnip-shaped, swollen stem. Showy varieties of *Tecoma* form a special adornment of the northern forests. A more beautiful spectacle is scarcely to be found within the vegetable kingdom, than that which is presented in the spring by these giant trees, which rank among the tallest of the globe; their bare wintry branches are clothed with millions of the large splendid blossoms, yellow or rose-red, which unfold before the leaves appear. All the trees we have mentioned, and many others besides, furnish, almost without exception, good, and some of them very valuable, wood, which is now used for little else than the manufacture of rough articles for the natives; almost all the household furniture being imported from Europe and North America. An increasing population, with its accompanying extension of trade, will find in the future a rich treasure in these trees, if they are well tended and preserved from ruthless devastation. The undergrowth is composed of terminalias, croton, a cinchona tree, and in many places wild oranges, which have probably sprung up from the fallen pips of the fruit, and degenerated into wild growth. Flowering herbs are rare in the shadow of the forest; bignonias and gloxinias being the only forms which deserve notice.

At the foot of the mountain ranges, in the wide valleys, and on the comparatively level slopes, a subtropical park-land is seen where sections of forest, isolated trees, stretches of bush and meadow-land, alternate or encroach promiscuously one on the other. Every incline of the soil is the cause of a different form of vegetation, and this influence would be still more clearly marked had not the hand of man interfered in manifold ways with the original condition of the soil production. For this park-land is the garden of the Argentine territory, capable of the richest and most luxuriant culture, and destined inevitably at some future date to be clothed with cornfields and gardens, rich towns and villages, where now herds of cattle graze and the exploration of the natural wealth of the soil is most imperfect. Even now, however, a considerable quantity of maize, rice, and sugar-cane is grown; and the orange groves of Tucuman are found far and wide, even beyond the ocean.

The kinds of trees which make up the larger or smaller forest lots or parcels are the same essentially as those of the high woods, but reinforced by other species which avoid the dense forests. The smooth emerald turf of the meadow-land which meets the traveller descending from the desolate Monte with such a homelike greeting is composed chiefly of *Paspalum notatum*, intermingled with *Mimosa sensitiva;* and on the pools, which are visited in winter by such incredible numbers of aquatic birds, by *pistias* and *azollas.*

Wandering still farther towards the east, we enter the region of acacias. The *Acacia cebil* is almost the only tree of these vast tracts of land, and its bark, which contains large quantities of tannin, renders it a valuable treasure; but as the natives only strip the bark from the lower part of the tree, as far as they can conveniently reach, the wood and the bark of the upper part of the tree are wasted and left to die. The last of the many divisions of the subtropical region is that of the quebracho colorado (*Loxopterygium lorentzii*), a tree whose feathery leaves emit a strong smell, and are said to raise blisters if handled for any length of time. Besides this tree we have only to mention the mistol (*Zizyphus mistol*), with its edible fruit and its bark, which is used instead of soap.

At a greater distance from the moisture-gathering heights of the Cordilleras the climate becomes drier, the noble trees of the subtropical forests give place to lower forms, the ground between the trees begins to be overgrown with bush, and patches of grass invade the forest, encroaching more and more upon its space. But, in a measure, all the moisture withdrawn from the atmosphere is conveyed in lavish abundance to the soil from underground sources. The slightly undulating plain of the Gran Chaco, which gradually slopes downward to Parana and Paraguay, is watered by some of the larger streams flowing in a serpentine course, and subject to sudden and extensive inundations, which lay large tracks of land under water, and isolate others, causing them to stand out like islands. When the flood subsides, it leaves behind numerous shallow lagoons, which occasionally remain without drying up during the whole dry season, and are used as *points d'appui* for settlements, especially forts and military colonies, erected against the wild Indian tribes, and used also by the latter as stations when they cross the wide forest lands of the Chaco. Indeed, were it not for these stations, and for a plant (as yet unnamed by botanists), with a very large root, which when scraped yields an almost tasteless, watery juice, and refreshes both man and beast, it would be almost impossible to cross the Chaco in winter. The higher undulations form a beautiful park-land, which, according to the statements of the residents offers a good prospect not only for cattle-rearing, to which it is at present almost exclusively devoted, but also to agriculture. The lower districts are chiefly forest land, the grassy plains inserted between them being of small extent, and consisting in part of worthless grasses and thickets of sedge and cane.

The higher trees of the subtropical forest land disappear more rapidly as we approach the coast; isolated species are still found to a considerable distance down the river, but new and peculiar forms appear; showy euphorbias, palo santo, to whose resinous wood popular belief ascribes wonderful medicinal properties, and many other trees as yet insufficiently known to science; lastly, in damp and marshy places, forests of wax palms (*Copernicia cerifera*), and a characteristic bush vegetation as undergrowth.

Turning to the true pampa, we find it a grassy plain, whose chief characteristic is the total absence of all wooded growths. The idea of the pampas gained in our youth from descriptions of popular books, in which they are depicted to our imagination as level plains with the sky-line for horizon like that of the sea, and upon which for hundreds of miles not the slightest rise of the ground can be perceived, is erroneous as far as regards the northern pampas of Santa Fè, though it is said to apply more correctly to the pampas of Buenos Ayres. The ground of the former is slightly undulating, and although the rise and fall does not strike the eyes as particularly imposing, it is nevertheless immediately perceptible by the difference of vegetation, and for the dwellers in the pampas it is of the highest importance for many practical reasons; to the European immigrant especially, whose observations are directed more towards agriculture than towards cattle-breeding; for although his eyes are compelled to recognise in these boundless plains a field richly favoured by nature for pastoral pursuits, he sees also that this fact by no means prevents them from also offering great advantages to agriculture. Many a rich estancia, with its waving cornfields and flourishing colonies proves the contrary. These settlements are chiefly confined to the cañadas, or flat depressions, where the lagoons provide the necessary water supply, or where at least water can be procured at a slight depth below the surface of the earth; where nature, by the increased number of flowers and the close, soft turf, indicates specially favourable vegetal conditions, and where the objects of culture find a more abundant and certain water supply, and draw more abundant nourishment from the virgin soil rich in solvable mineral substances. In the closer and finer turf (*Pasto blando*) are found all kinds of plants belonging to different families; a vegetation of different growths changing according to the amount of salt in the soil, and the contribution of moisture from the fleshy-leaved *portulak*, which occasionally provides even human beings with wholesome and agreeable food, to the vivid colours of many gorgeous blossoms, nearly all of which afford rich and fattening pasturage for cattle. Besides the *portulak* we may mention verbenas, especially a beautifully scarlet verbena, composite plants, mallows, *papilionaceæ*, and euphorbias.

The shallow rising ground of the pampas is drier, and its vegetation is marked by peculiarities which strongly arrest the attention of Europeans by the contrast which they present to his native land. There is nothing here resembling the smooth, luxuriant, rich grassy turf of our meadows, with their wealth of flowers; but scattered tufts and bunches of coarse grass (*Pasto duro*), chiefly consisting of broom and pearl grass (*Stipa* and *Melica* varieties), which rise in isolated bunches from the yellow-brownish clay soil. Where this formation is most marked, the naked soil is often washed away and carried off by the rain, so that the grassy tufts are left growing on actual ridges; often, however, especially in a favourable time of year, it is covered with all kinds of tender grasses and shrubs, with few, but in some cases brilliantly coloured, varieties. The eye sees the pampa as an enclosed, grassy plain, clothed according to the time of year in different colours; coal-black in spring when the old grasses have been burnt up, vivid blue-green when the young leaves first appear, brownish green later on; and lastly, when the silvery white of the blossoms rise above the turf, presenting the appearance, as far as the eye can reach, of a rolling billowy sea of liquid silver.

The absence of trees on the pampas is a fact which has never as yet been satisfactorily explained; but which appears all the more singular because the soil is by no means unfavourable to tree growth. A whole collection of tree forms might well be planted, and would sufficiently meet all the demand for wood, even if it were greater than it is, but the inhabitants prefer their dung fires to the use of wood as fuel. Among the trees which thrive readily and luxuriantly are the peach, which supplies not only fruit, but wood, the orange, a few species of eucalyptus, the robinia, the Italian poplar and others; but the culture of many other kinds is rendered almost impossible by the ants. The most striking tree is the ombu (*Pircunia dioico*), which is cultivated for its shadow, but is good for nothing else. The character of the pampas is changed by pasturage, especially by the sheep grazing; the hard, isolated grasses disappear, and make way for a close turf of softer and lower varieties. But the cattle breeder cannot afford to dispense with the *pasto duro;* its long bunches dry up after the season of bloom, and become like straw, losing in the process much of their nutritious juices, but yet affording even in the severest drought a fodder on which cattle are able to exist for months together.

In many places immigrant plants have gained the day over the native vegetation, dislodging it, and thereby changing the appearance of wide stretches of the pampas. This has happened in the case of several species of thistles, especially the *Cynara* cardunculus, burdock, and fennel. From the seeds of the first-named plant, which has now taken the place of the pampas grass for many square miles, it is thought to be ascertained that they were brought over from Spain in the year 1769, in the hair of an ass. The plant now forms impenetrable thickets, six feet in height, and when in full bloom forms such an effectual rampart, that certain districts are sufficiently defended by it against the raids of the Indians of the Chaco. In like manner, many other of the imported trees are found to thrive beyond all expectation; and even the barren district of Mendoza is said to be so altered by the introduction of the Italian poplar, that it looks from a distance like a large forest.

If the continued plantation should at any time result in a universal forest growth, the climate would doubtless alter, and instead of the abrupt alternation of drought and violent gusts of rain which now prevail, a more uniform distribution of moisture would ensue. In that case the conditions of agriculture, which is now only practicable in a few places, would also be improved. But it is yet an open question whether any such transition from pasturage to agriculture be on the whole desirable, and whether it may not be better, in the interests of the world at large, that there should be, besides corn-growing countries, others reserved for the supply of stock to exchange with the produce of the former, and to send into the markets of the world flesh, hides, wool, and other articles of similar nature.

About the year 1540, bulls from Spain were introduced into the southern countries of America, where the climate was found to suit them so admirably that they soon shook off the restraint of domestic service, and escaping from their somewhat careless keepers, freed themselves entirely from control. A hundred years later they overran the pampas in such numbers, that they were hunted down and killed solely for the sake of their hides. Before the province of La Plata was destroyed by the civil war, nearly a million hides were exported annually from Buenos Ayres. A singular society, that of the "Vaqueros," was

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formed from among the inhabitants; men who were accustomed to risk their lives for a few pence—daring, reckless fellows, who confronted the bulls with the lasso, and managed to subdue them by means of that apparently feeble weapon. Many landed proprietors owned on their immense estates from eight to ten thousand head of cattle, which were scarcely kept under any supervision, and at the proper time were driven into a fold or enclosure, and either shot down wholesale or driven out singly, pursued by the shepherds, and brought down by the noose, and killed. The flesh and fat were left for the wild and tame dogs, and for the vultures. Butcheries of this kind soon thinned the ranks of the immense herds, and it is only lately that better management has led to a change of the former reckless method. According to Napp, the number of cattle in the Argentine Republic amounts to from thirteen to fourteen millions, and in Fray Bentos (Uruguay) alone five thousand a day are slaughtered for the manufacture of extract of meat. But so far from adding butter and cheese to the list of exported articles, the States of the Republic send annually large sums of money to Europe to purchase these wares; and on cattle-rearing farms possessing from ten to twelve thousand cows, or even more, butter is almost unknown, and even milk is considered a rarity.

According to the American archives of Seville, the horse was introduced into La Plata by Don Pedro de Mendoza, who took with him thirty-two animals for the needs of his colony. Some of the horses were lost in the desert places before the others were killed for food by the settlers. When, at a later date, the energetic Garay led a new band of colonists to the settlement which had dwindled away since Mendoza's time, and became thus the true founder of Buenos Ayres, the fugitive horses, now completely wild, had greatly increased in numbers, and formed the stock of the countless troops now found in La Plata. From that time their numbers have attained extraordinary proportions, and there are supposed to be about four million horses at the present time in the Argentine Republic. Unfortunately, however, the breeding and training of horses has not received that degree of attention which it deserves. In the coast lands, sheep breeding is very important; and farther towards the interior large flocks of goats (*Tucuman goats*) are reared; the number of sheep is estimated at 57½ million, and of goats at nearly 3,000,000. Swine and poultry, on the other hand, are much neglected; the latter especially, so that in some towns an egg costs about fourpence, and a fowl five or six shillings. On the whole, the average value of the cattle in the year 1876 was said to be £50,000,000, so that the value of the live stock was more than £20 for every inhabitant.

The farther we advance eastward from the ocean, the drier the climate becomes, and as a necessary consequence the flora and the Monte formation change, and we enter upon a tract of bush and forest land. Why this dry climate, in contrast to the moister one of the pampas, should bring forth a vegetation of wooded growths, is not as yet clearly understood; but almost all the trees and shrubs of which this formation is composed are, owing to the drought, of low, often stunted growth, with rough, wide-spreading branches, and leaves generally either stinging or set with thorns.

Accordingly, one of the most characteristic growths of this formation is the mimosa tribe, especially the *Prosopis alba;* together with this, we find celtis and terebinths, verbenas and chañar (*Gourliœa decorticans*), are also common, the latter especially being found in such abundance as to have caused Griesbach to give to the whole district the name of chañar steppes. This plant and *Condalia microphylla*, a cruciferous plant, yield sweet, pleasant-flavoured fruit; capsicum or Spanish pepper is also found. Euphorbiaceæ are represented by the singular *Jatropha* and *Manihol* varieties, and by the croton and castor-oil plants. Cacti are numerous, the lofty column cactus, their largest representative, growing in the west desert part to the height of thirty to thirty-six feet, and supplying timber for all sorts of carpentering and even for house-building. Equally numerous, indeed more so in some places, are the opuntias, which sometimes rise to the height of twenty to twenty-four feet, and are very often of branching growth, and sometimes scarcely rise above the ground. One variety (*Tonas*) bears the Indian fig; other kinds harbour the cochineal, which ought to command a great commercial future as an article of exportation. In the province of Cordova rise great palm forests (*Copernicia campestris*). The desolate aspect of the small straggling shrubs, with their scarcity of leaves, is relieved by several creeping plants, some of which have large and showy blossoms (mikania, wild vine, bindweed, convolvulus, and others). The grasses are principally broom and pearl grass; besides them we need only mention *Arundo occidentalis*, a mountain plant which is sometimes erroneously described in books of travel in the Pampas as *Gynerium argenteum*, and called pampas grass. "If," says Lorentz, "the pampas really contain a gynerium, which I have not as yet been able to establish, it is certainly some other kind." Among herbs, bulbous plants are poorly represented, and the chief place is occupied by beautiful flowering growths, foxtail, alternantheræ, groundsel, eupatorium, burdock (*Xanthium*), wild grape (*Salpichroa rhomboidea*), yielding fruit as large as a pigeon's egg, single instead of growing in clusters, and tasting like wine; beautiful but poisonous nierembergias, petunias, tobacco plant, verbenas, green sorrel, and often salsolæ. Salicornia is also found, and near the settlements the immigrant plants agave and sedge (*Arundo donax*).

At the foot of the Cordilleras, the Monte gradually changes to an actual desert: the mountains allow no moisture from the Pacific to reach the plains; and from the east all the vapours are absorbed by the projecting sierras. The climate is consequently of extreme dryness, so that even the flea disappears. Rain is very rare, and culture is only possible where the high mountains send down a stream or brook to the plain. Where the valley widens, these streams create oases, which form the homes of small settlements. The water is then sufficient for a certain number of flowering plants and fields of lucern, and also for splendid vineyards, which completely absorb it; so that below the village the river bed is dry, and only able to carry down water to the desert during the short periods of the transient inundations. But wherever the vines meet with intelligent treatment, the wine yielded by them may safely challenge comparison with those of any other spot upon the surface of the globe. An important article of food for cattle is obtained from the algaroba forests, which in good years lavish their bounteous gifts for the welfare of man and beast, but their yield is very uncertain. Generally, alternate crops of maize and algaroba are obtained; but if both should fail, the traveller will often find it difficult to procure a sufficient supply of fodder for his cattle, even for a single night.

The name Pampas is given throughout the whole of Patagonia to the high, undulating table-lands. The Indians indeed, who understand a little Spanish, apply the word indifferently to every tract of land over which they hunt. Those whose ideas of the pampas are taken from the descriptions of the boundless, grassy or thistle-covered plains of La Plata, those undulating stretches of land across which the unwearied gaucho hunts at a gallop for days together, must not transfer their ideal picture to the Patagonian pampas. The latter, in some places, especially in the lower-lying districts, certainly present occasionally the appearance of undulating plains covered with coarse grass; but, as a rule, the ground, even when broken by heights, or opening in some abrupt ravine, is sterile, only shewing a scattered growth of vegetation, consisting of stunted bushes and round clumps of thistles. In some places even these are wanting, and the bare clay or gravelly soil is entirely uncovered; in other places the ground is covered with large loose rubble; and in others again, especially in the northern districts of the country, it is broken by a chaotic confusion of bare, sharp-edged rocks, many of them of volcanic origin. The only uniformity to be found within the region is seen in winter, when rock, grass, and gravel are alike buried beneath their white shroud of snow. The first place among the grasses is claimed by the pampas grass (*Gynerium argenteum*), next to which comes the canary grass (*Phalaris*). Reed-mace (*Typha*), willow, shavegrass, a few salt-worts (*Salicornia*), a number of cacti, algaroba, and in the spring a heron's bill (*Erodium*), compose the flora of this very imperfectly known formation, which is said to have only two seasons, a long, but not very cold winter, and an inclement spring. When I recall pictures of the past (says Darwin), I find that the plains of Patagonia frequently appear before my eyes; and yet all these plains are described by travellers as wretched and worthless. They can only be described by

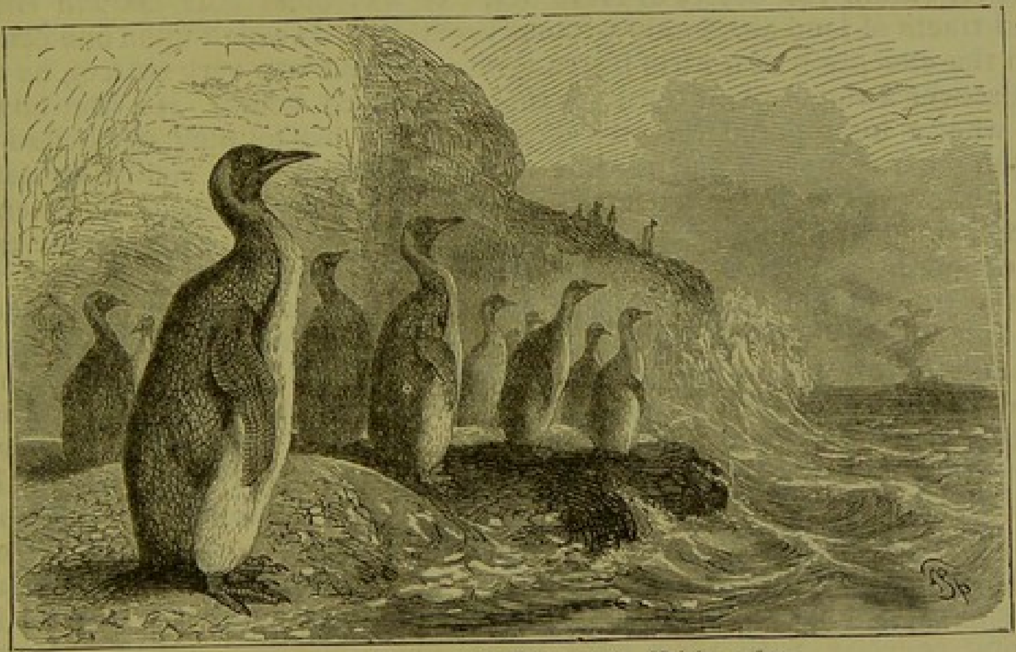
PAMPAS GRASS (*Gynerium argenteum*) AND IBISES.

negatives—without habitations, without water, without trees, without mountains, they only bear a few dwarf plants. Why then, for the case is not peculiar to myself, have these barren wastes won for themselves so strong a hold upon my memory? Why have not the more level, verdant, and fruitful pampas, which are of more use to mankind, produced an equally deep impression? I cannot analyse the sensation, but it must be the result of the unfettered freedom accorded by them to the fancy. The plains of Patagonia are limitless; for they are scarcely possible to be explored, and are consequently little known: they bear the imprint of having existed just as they are now for centuries; and there seems to be no limit to their duration through future ages.

The animal world of the temperate regions of South America is comparatively poor; but it is very imperfectly known. Various kinds of apes and monkeys abound; among others, the black howling monkey (*Mycetes Caraya*); the *Cebus fatuellus, Callithrix personata,* and *Hapale pencillata,* are said to be found only in the forests on the Uruguay, Parana, and Paraguay, as well as near the Brazilian boundary, that is, in the districts which belong to the Brazilian sub-region. Carnivora are represented by the jaguar, puma, a few wild dogs, together with the *Canis azaræ,* the galictis, an animal resembling the marten, a skunk (*Mephites Patagonicus*), which is said by Musters to be kept as a domestic animal by the Tehuelcas, an otter (*Lutra paranenis*) and two nasuas. Seals are represented by a kind of *lephonix* found on the coast. The pampas stag (*Cervus campestris*), is often seen, startled by the steam engine, and fleeing before the train along the line from Rosario to Cordova. Peccaries and tapirs belong to the northern districts, and are scarce even there. Bats are poorly represented, rodents are numerous; among the latter are the curious coypu (*Myoptamus coypu*), on the banks of the Parana, the crested rat (*ctenomys*), the pampas hare (*Dolichotis Patagonicus*), the pampas rabbit (*Lagostomus trichodactylus*), a few guinea-pigs (*cavia*), and the curious water pig (*Hydrochærus capybara*), the largest and most remarkable of the rodents. Among the interesting order of edentata are found several armadilloes (*Dasypus*) and the *Chlamydophorus truncatus;* the opossum tribe known to us in North America is represented chiefly by the *didelphis azaræ.* Especially numerous, to conclude with the mammals, are the whales found near the coast. According to Barmeister, they are represented by fourteen species, of which the principal are the spermaceti, or white whale (*Physeter*), the giant whale (*Sibbaldius*), the long-finned whale (*Megaptera*), a *Balænoptera, Phocæna,* and three dolphins.

The bird world is both numerous and diversified. Ranging from the ostrich to the humming-bird, and from the condor to the penguin, it includes a rich variety of species, and represents the widest differences of form, size, and manner of life.

Carnivorous birds are represented by a few vultures, numerous falcons, including the *Carancho, Caracara* and *Polyborus tharus.* The most common of the many kinds of owls is the *Speotylo cunicularia,* constantly seen standing before the entrance to the burrows of the prairie rabbits, and sharing their underground dwelling, just as their northern kindred, the prairie owls (*Speotylo hypogæa*) live with the dogs of the northern prairies. Parrots are found in great numbers; the pretty *olborhynchus monachus* being so plentiful, that they are bought at so much a dozen, and, according to Darwin, 2,500 were killed in one year at a single settlement. Barbets, cuckoos, and woodpeckers, called by the inhabitants carpenters (*Carpinteros*), are not scarce. Sparrows and thrushes, waders, pipits, and a kind of starling (*Molobrus*), which, like our cuckoo, lays her eggs in the nest of other birds. Hilltits (*Liochtrichidæ*), finches, tyrants, *Icteridæ,* tanagers and *Eriodoridæ* are less frequently observed. Among the countless and beautiful little humming-birds, the most common is the pretty gold-green *Trochilus flavifrons.* Ravens are represented by the stately blue-crested crow (*Cyanocorax pileatus*), kingfishers, sailor birds, and swallows are not absent. While pigeons and doves present little of interest, gallinaceous birds are numerous, including the partridges or *Perdius* (*Crypturus* and *Rhynchotus*) whose smoothly polished eggs and savoury flesh are held in high estimation; the great hokko fowl, or curassow, peculiar to South America, is represented here, though only in the north, by the *Penelope* or guan, and the large black curasssow (*Crax alector*), which has a yellow fleshy protuberance at the root of its bill. The only species of running bird is the *nandu*, or American ostrich (*Rhea Americana*), which is tolerably common throughout the whole region, and is in some places kept tame in the house or on the farm. Its eggs are much valued for their size and delicacy. Attempts have lately been made, with considerable success, to improve the breed of the nandu, by crossing it with the African ostrich, in the hope of obtaining finer feathers for the markets. Wading and aquatic birds have not as yet been sufficiently studied. In the north is found a screamer (*Palamedea*), and a stork (*Dicholophus Burmeisteri*) is frequently kept in the poultry yards. Several varieties of heron and ibis are found, and the stork (*Ciconia maguari*) is very common. Long-shanks (*Tatanus*), snipe (*Scolopax*), sandpipers (*Tringa*), plovers (*Charadrius*), rails (*Parridæ*), with the long-toed jacanas (*Parra jacana*), armed with spurs at the tip of its wings, gulls, grebes (*Podicipinæ*), flamingoes, swans, including the black-necked swan (*Cygnus nigricolis*), geese, and ducks abound; finally, the curious anks are represented by the giant penguin (*Aptenodytes Patagonica*), and perhaps by other species also.



GIANT PENGUIN (*Aptenodytes Patagonica*). Height, 3 feet.

Land turtles are rather common in the pampas, but fresh-water turtles are rarer; sea turtles are represented by the large *Chelonia midas*, sometimes six feet in length, and the *Chelonia imbricata*, four feet in length, which are found near the coast of the Atlantic. The Parana affords shelter to the caiman (*Alligator sclerops*). The lizard of Teju (*Teju tejuixin*) is feared and hunted down as a marauder and robber of eggs and poultry. Agamas gekkoes, smooth-skinned and ringed lizards (*amphisbaenæ*) are well represented, as also is the snake family, by the rattlesnake (*Crotalus horridus*), *trigonocephalus alternatus*, numerous adders and worm-snakes (*thyphlops*), while amphibia are comparatively scarce. Fishes have as yet been very imperfectly classified, but they offer nothing of special interest.

The lower animal world is unusually well represented; for as the Argentine States occupy about the twenty-fifth part of the earth's solid surface, they ought also to possess about the same proportion of insect species, namely, 3,200 kinds; while as a matter of fact the number of native species is already estimated at 8,000.

Curious and striking, even in the eyes of the inhabitants themselves, are the so-called *Franceses* or Frenchmen, species of bombardier beetles (*Brachinus*), which "immediately begin their cannonade whenever touched, and emit a strong odour;" numerous fire-flies *Pyrophorous lampyris*, etc.), which swarm round the camping place toward evening; thin rod-shaped spectres, or phasmidæ (*Bacillus*), sometimes six inches long; locusts of the most diverse colouring and sizes, often threatening the crops with serious danger; ticks (*Garrapatas*), which torment almost every mammal; scolopenders of six inches in length, centipedes (*Julus*), and scorpions two and a half inches long.

Nothing new is presented by the fauna of Chili and the Antarctic forest region, to which our attention must now be directed. The characteristic animals of Peru, and some of those belonging to the Argentine Republic, are also characteristic of Chili; while nothing is known as yet of the forest region. Botanically speaking, Chili forms a transition territory, extending from the tropic almost to the arctic zone. On the northern limit of the region the traveller enters the desert of Atacama. It was there that Darwin encountered tracts of land absolutely without vegetation, on which upon one occasion, with the exception of a little lichen (and even that was very scarce), he failed to discover a single plant during a ride of fourteen hours. He was, however, not wholly unprepared for this experience, as his journey northward from Coquimbo to Copiapo had already familiarised him with similar formations. But although the latter appeared when seen from a distance to be equally barren, there was seldom a space of a hundred steps where a careful examination might not have detected a small shrub, a cactus, or a lichen; while on the ground lay the germ-bearing seeds, only waiting for the touch of the first chance shower. The coast lands of Chili also are almost entirely destitute of forest, only one of any magnitude being mentioned on the bay of Quintero, not far from Valparaiso, and even that is described as without beauty, and altogether wanting in tall, fine timber trees. As we advance, however, from the coast toward the interior of the country, the flora gains in attractiveness in its winter and spring attire, by the beauty of its separate component parts, the flowering shrubs and bushes. This is the land of the woody growths of the *Boldu*, acacia, soap tree (*Quillaja*), and *Jubæa*, shading through every tone of colour, and draped with elegant climbing plants; intertwining colletias, with their hard wood, mingling with cactus and ananas growths, and woven together into an "*espinal*" or thorny impenetrable thicket. Then follow grass-grown rocks with orchids, or stretches of hard clay soil with bulbous growths; then again a picturesque bushwood of flowering shrubs, and on the last gradation of the hill a dry, dusty tract of land, where the woody compositæ appear in scattered groups. But everywhere the formations, like the regions, are connected together by gradual transitions, until the summer lays them all alike waste and desolate.

The period of vegetation in Chili runs through a similar cycle to that of the Mediterranean region, but is interrupted for a longer period by the dry season of the year. In Santiago the flowering season begins in the middle of July, as from the beginning of winter (that is, since the month of June) rain has moistened the earth, and by the end of November the period of vegetation is ended everywhere, the rains having ceased as early as September or the beginning of October. There is now a period of more than six months, during which no running water is at hand to moisten the woody growths, so that the plant life seems dead, and the whole country has something of the aspect of a desert. Then, upon the bare hillsides, only the cactus growths (column, prickly, and verrucose) are able to preserve their sap. Even the more humid coast of Valparaiso has only obtained its name of Paradise from its beautiful garden-like appearance in spring. Grand as is the scenery of Chili, with its views of the near snow mountains and volcanoes, which extend in a long line across the eastern horizon, yet the physiognomy of its vegetation presents none of those beautiful forms which constitute the charm of the Mediterranean region. One misses the lofty tree-growth; the foliage of the shrubs is choked by thorns; the transient spring bloom bears no proportion to the long periods of desolation, which are intensified by the barrenness of the mountain ranges. For, throughout almost the whole extent of the Chilian transition flora, the Pacific slope of the Andes, with their subordinate mountain chains, occupies the whole space from the snowy peaks of the Cordilleras to the coast. Untouched by the sea winds, the rubble of the slopes everywhere protrudes above its scanty vegetal covering.

The mountains, with the luxuriant fodder growths of their well-watered valley and ravine, are better suited for cattle-rearing than for agricultural purposes. It is only in the neighbourhood of Santiago, where one of the Cordilleras separates itself in a southerly direction from the principal chain of the Andes, that we enter the beginning of that great and extremely fertile longitudinal valley which has obtained for southern Chili the title of the granary of the South American coast. Whence, however, arises its lack of trees? It is thought to be the result, not of the dryness of the climate, but of the unfruitfulness of the crust of the earth; for the stems of native species are stunted, and tend to give place to shrub even where immigrant plants thrive admirably, and where European fruit trees, and even certain tropical fruits, such as the *Cherimolia*, are grown in great abundance.

The rich luxuriance of the antarctic forest region in the south, from about 34° S. lat., is the result of the influence of the moisture-laden ocean climate, with its slight alternations of temperature in the different seasons which it produces. To this influence Chili owes some of her richest provinces, for instance, Valdivia, where the wild apple grows so freely, that, according to Philippi, the brooks and rivers in the autumn months carry down millions of apples to the sea; and which is probably the home of the potato, and of the *Madiasativa*.

This forest land extends as far as the inhospitable districts of Maghaelhan's Straits, and even surrounds Terra del Fuego with a belt of forests, which, however, gives place, at a moderate height above the sea level, to an alpine vegetation; the lavishness of the flora decreasing as the vicinity of the south pole lessens the amount of heat.

The Chilian araucaria, or Andes fir (*Araucaria imbricata*), the splendid tree which lends such an unique charm to our gardens, grows only on the two Cordilleras of Araucania (37—39 S. lat.), but in that place it attains, as do many other trees, to the height of more than 90 feet. As far as the island of Chiloe, or thereabouts, the forest has the character of a virgin tropical forest, which is imparted less by the presence of tropical vegetal forms, than by the climbing plants and epiphytæ clinging to the trees; bromelias, smilaceæ, rare ferns, etc., with an impenetrable undergrowth of bamboos. In the southern districts the bamboos are replaced by evergreen shrubs of the oleander, myrtle, and heath forms; and beautiful flowering fuchsias and veronicas contribute their floral adornments to the forest. The chief characteristic trees of the woods are beech; but as the prevailing type, which sheds its leaves in winter (*fagus antarctica*), is accompanied, even in the south, by an evergreen beech (*fagus betuloides*), the aspect of the forest is widely different from the beech woods of Northern Europe. In Terra del Fuego the trees grow to the height of 900 to 1,500 feet, above which rises a tract of turf land, with small alpine plants, until at the height of 3,000 to 4,000 feet the snow-line is reached. Level ground is exceedingly rare, and is covered by a thick layer of swampy turf. Even in the interior of the forest the ground is hidden beneath a stratum of slowly putrefying vegetable substances, which, being permeated by water, yields to the tread. On every side lie irregular masses of rock and fallen trees, while other trees, although still standing upright, are decayed to the core, and ready to fall.

Only some three hundred miles distant from the coast of Chili lies the island of Juan Fernandez, limited in extent, but distinguished by its living creatures. Easily as an immigration from the continent might have been effected, yet the woods are nevertheless animated by birds exclusive to the island, namely, by humming-birds, which, like the trees in which they build, are found nowhere else on earth. By the preponderance of ferns, tree-fern, and palms, the vegetation approaches to the characteristics of the New Zealand flora, but the forest trees are composites, especially hiccory (*Rea*), found mingled with a peculiar palm (*Ceroxylon Australe*).

Not much farther from the coast than Juan Fernandez, and opposite to Patagonia, lies the celebrated archipelago of the Falkland Islands, whose monotonous flora corresponds with that of the mainland near the Maghaelhan's Straits. Destined by nature for a pasture land, where, however, before the introduction of flocks, penguins and other sea birds dwelt alone, these islands are entirely covered with long grass (tussock grass, *Dactylis cæspitosa*), which grows over widespread beds of turf.

CHAPTER V.

AUSTRALIA.

THE AUSTRAL CONTINENT.

THE climate of Australia, that is, of the Austral continent, to which, for the present, our attention must be exclusively directed, is the product of three factors: its situation on both sides of the tropics, its lack of mountains, and its wide extent of plain. Accordingly, the north is marked by tropical heat and summer rain; the interior, from 19° to 30° S. lat., is a zone of desert; and beyond that parallel the moisture is confined to the winter months, until finally, in Tasmania, even the drought of the dry months disappears. But these general features are subject to manifold variations. At first, one would be ready to think that the south-east trade-wind, which reaches the east coast laden with a plentiful supply of moisture, must create an extremely humid climate. Such, indeed, is the case in the immediate vicinity of the sea; but at a very short distance from the coast mountain terraces bar the further advance of the treasure-laden wind; and as the latter only strikes the shore in a slanting direction, it swerves aside, and just passing over the edge of the mainland, veers northward to New Guinea. Meanwhile, the over-heating of the continent in its tropical districts creates the burning desert winds, which sometimes penetrate to the southern coast. Under their influence the thermometer rises above 104° Fahr., delicate flowers shrivel up at the first break, all verdure is dried up like scorched paper, and whole fields of corn, barley, and other cereals are perfectly singed and rendered good for nothing but to be used as straw; and if from some more humid climate a cloud stratum should, we may almost say, lose its way, and stray into the fiery desert, it is immediately absorbed. The conglomerated masses of moisture, which seemed to promise help and solace to the fainting traveller, driven by the impulse of scientific enquiry into these inhospitable solitudes, die away before his eyes, and hunger and thirst kill some of the best of our race—a Burke, a Becker, a Leichhardt, and many others. Australia has, indeed, been called a waterless country, but enquiries recently instituted shew that this is by no means the case. Thus the annual rainfall in Sydney proves to be twenty-six inches, which is the same as that of the south of Germany, but the distribution is altogether different. In Europe a moderate rainfall is distributed with tolerable evenness throughout the whole year, while the Australian sky sends down, in a very short period, an immense downpour, after which the blue vault of heaven looks for a long time as if it had never been crossed by a cloud. On two occasions, at Sydney, the unusual rainfall of more than thirteen inches was recorded within twenty-four hours, a mass of water equal to that which in London makes up the rainfall of the whole year. It is this circumstance which is decisive in the consideration of organic life; for the plant world depends, not upon the amount of moisture, but upon its steady supply.

With respect to its flora, Hooker has divided Australia into three vegetal regions—a northern or tropical, a south-eastern, and a south-western. We are prepared to find that the northern region, which belongs to the tropic zone, has a marked impress of its own; and our wonder is aroused when we find its flora varying so slightly from that of the south. Several gum trees (*Eucalyptus*) grow in both regions, and under the same conditions; sandal-wood, myrtles, and *Leptospermeæ*, including, among other varieties, cajeput, eucalyptus, and iron-wood (*Metrosideros*), which form here, as there, the principal components

ACACIAS OF THE AUSTRAL CONTINENT.
1. *Acacia smilifolia*; 2. *A. lineata*; 3. *A. pentadenia*; 4. *A. platyptera*; 5. *A. galioides.*

of the *bush*, as the colonists please to call these forest regions. But the north nevertheless possesses characteristic plants of exclusively tropical nature. Chief among their number are the singular shapeless Adansonias, the bread-fruit trees of the colonists, the baobab, or monkey bread (*Andansonia Gregorii*), trees with gouty trunks.

From a low trunk, scarcely twenty-one feet high, but often measuring fifteen feet in diameter, rise comparatively meagre, straggling branches, forming an odd contrast to the whole surroundings, especially when, having lost all their leaves, they stand among the glossy evergreens, and display their naked, barren branches laden with thousands of cucumber-like fruit, from whose shell exudes a red gum. Inside the shell the seeds lie hidden in a very acid, but pleasant-flavoured and refreshing pulp. We must also mention among the eucalyptus the blue gum tree, or fever tree (*Eucalyptus globulosa*), whose wide-spreading roots draw up the water, and so drain the soil, while it exhales aromatic odours which destroy the foul-smelling miasmas by which the fever is produced. While on this subject, we may remark in passing that the Italian Government some years ago made arrangements for the culture of these trees on a large scale, and as early as 1875 had 5,000 young trees planted, at its own expense, in the marshy soil of the Roman Campagna. One result of the plantation was that the malarious fever abated, and, in course of time, completely died away.

In humid districts, shadowy palms, slender *Bangala* palms (*Seaforthia elegans*), and stately cabbage palms (*Livistonia Australis*), combine to form pleasant groves, while the river banks and the borders of the grassy plains are framed with close rows of cajeput trees (*Melaleuca*); indeed, in the latitude of the Gulf of Carpentaria there are also Pisang (*Musa*) and bamboo. Generally speaking, the wood is shadier here than in the south, thanks to the presence of the eucalyptus, whose kindred shadeless varieties are found there in great numbers. On the rising ground situated in the north-west, a cypress pine (*Calitris verrucosa*) reaches the height of seventy-five feet, whose trunks, which are often eight feet in diameter near the ground, yield excellent masts, nearly equal to those obtained from the Cowri pine. On the higher mountain chains of the north-east are found, together with the magnificent Norfolk pine (*Araucaria excelsa*), which grows to the height of 180 feet, the beautiful *Araucaria Bidwilli*, the Moreton Bay fir (*Araucaria Cunninghami*), and the singular bottle tree (*Delabechia rupestris*), with its trunk measuring nine feet in diameter, and resembling a gigantic onion in shape.

The flora of the north-west is the least open to the reproach so often cast upon the flora of the Austral continent, with regard to its scarcity of sweet-smelling flowers. *Labiatæ*, rue worts, and fringe myrtles (*Chamælancieæ*), exhale fragrant odours; and the lovely white and delicately tinted yellow azaleas shed abroad a fragrance like that of thousands of violets through the warm air. The numberless kindred of these plants are scarcely twelve feet high near the mangrove forests of the coast; but when removed from the repressive effects of the presence of the sea, they shoot up to the height of 100 feet; and, with their massive, flower-laden crests, present a magnificent spectacle; while the air is penetrated with their fragrance to a great distance on every side. The wide grassy plains, of which there is no lack in the north, are often treeless; only meagre bushes of *Chamælanceæ, leptospermeæ*, and myrtles relieving the monotony of the prairie-like expanse.

In the north-east, on the banks of the Glenelg and the Fitzroy, the grasses reach the height of twenty-seven feet, and cover the low plains in dense masses. As we advance southward, we find the grass growth weaker, the grass shorter, and growing in separate tufts.

According to Drude, the palms of Australia are far from possessing the wealth of species and number of individuals which characterise those of the neighbouring islands, particularly of New Guinea. It is true that twenty-five different species are already known; but they are scattered over a very long stretch of coast, and never make up plantations of any great extent.

The north, from what has been stated above, possesses no uniformity of flora; but its diversity arises from the different conditions of its vegetation. The contrary is the case in the south. First of all, the difference of the flora of the south-west from that of the south-east is so complete that it aroused the wonder of the first discoverers, until Robert Brown, and more especially Hooker, stated clearly the contrast. At present there are known about 90 families, 600 genera, and 3,600 species in the south-west; and 125 families, 700 genera, and 3,000 species in the south-east. According to Dr. Jung, there are more than 900 species of papilionaceous flowers recognised in Australia, of which 420 species belong to the south-west, and only 280 to the south-east. Of the rich genus, the acacia, 99 species belong to the south-west, 133 to the south-east, but not a single one is common to both districts. The myrtle blooms also are much richer in forms in the smaller and drier west, than in the moist and fertile east. Of 680 species, only twenty are found in the north, 200 in the east, and 400 in the south-west. The genera *Verticordia*, *Calothamnos*, *Genethyllis*, and *Beaufortia*, possessing respectively fifty, twenty, and fifteen species, belong exclusively to the south-west. The case is almost the same with the *Protaceæ*, 400 of the 650 species belonging to western Australia; while the number of the *Epakrideæ* is greater in the east than in the west, only 160 species being found in western Australia, against 170 in the east. But of the fifteen south-west varieties of *Hakea*, only one is found in the south-east; and not one of the seventy-eight *Grevilleæ*, thirty-eight *Banksias*, and twenty-five *Personias*, which belong to the south-west, are found in the south-east. In short, of the 600 genera of the south-west, 180, which comprise nearly 310 species, are either absolutely wanting in the south-east, or are found in rare and isolated instances. The east has, it is true, its own species, which are exclusive. One-third of the genera of the south-west, and one-sixth of those of the south-east, are made up of pure Australian types.

Notwithstanding its greater diversity of species, the west is far from equalling the east in the magnitude of its flora. It is true that in the south-west we find the eucalyptus, known as the mahogany tree (*Eucalyptus marginata*), one of the most valuable Australian timber trees, which, like teak, is able to withstand the attacks of termites and burrowing worms; and that the *Eucalyptus colossa* in the valley of the Warren grows to a height of 300, or even 370 feet; but of the 950 species which exceed the height of thirty feet, only eighty-eight belong to Western Australia; while the east exhibits in its gum trees (*Eucalyptus amygdalina*) giant forms of more than 500 feet in height; for, as the colonial papers boast, the Australian eucalyptus excels the Californian Wellingtonia in height, though not in the size of its trunk.

To the question why the two creative centres of the south, in the east and west, never exchange their productions; why the various kinds of *Hakea*, *Grevilleæ*, and *Banksias*, do not advance eastward, and why the acacias of both divisions, although requiring the same conditions of existence, are not found side by side, an answer is obtained by casting a single glance upon the map. We see there, extending for several degrees, a tract of land situated on the 130° east longitude (Greenwich), bearing the ominous titles Treeless Plain and No Man's Land. This district apparently extends from the northern to the southern coast, a desolate, hopeless wilderness, and explains why the centre of the map is left almost blank. The construction of the ground and the absence of water exclude every hope of useful culture. Northward and southward extend boundless stretches of land covered with the notorious porcupine grass (*Spinifex, Triodia pungens*); from close turfy roots there rise in every direction stiff, bristly grass, from one to six feet high, forming unapproachable mounds, across which horse and rider make their way with the greatest difficulty. Like monstrous fields of barley, the grassy covering of the plains waves in the wind, forming an impassable barrier for more delicate plant growths. The waste desolate plain, bestrewn with rubble of granite and sandstone, and here and there broken, but not relieved, by a series of salt marshes, lies outspread between eastern and western Australia. To the north and the south, these never-ending plains are separated from the sea by a comparatively fertile stretch of land; large reaches, almost destitute of trees, closely grown with orache (bluebush and saltbush, *atriplex*) and grass, only want water to make them into valuable pasture lands. But water is not to be procured, and wide plains, intersected with large mounds of driftsand, separate the comparatively fertile belt of land from the stony wastes of the interior. Extending in parallel lines from east to west, the sharply defined ridges rise to a height of thirty to sixty feet. Very few oases are to be found in this gloomy corner of the earth; and these are situated round little springs, and occasionally, like that near the Weld Springs, exhibit a comparatively rich vegetation, with the white gum tree (*Eucalyptus acervula*) as the characteristic plant; and are frequented by numerous kangaroos and emus, together with other marsupials and some birds. How scarce these more cheerful landscapes are, may be best perceived by the fact that Giles journeyed from the 129th to the 124th degree of longitude without finding one piece of standing water or one running stream.

And yet the so-called waterless continent is by no means lacking in watercourses. Numerous streams and rivers are marked on the map, and most of them carry down a considerable volume of water; but they all without exception, have the unfortunate habit of running dry at long intervals, and only leaving in the deeper hollows of their bed, which then forms a valley and thoroughfare, a succession of disconnected pools of water, reservoirs of moisture separated by stretches of dry land.

As the grass land is the blessing of the country, so the scrub is its curse. A useless, impenetrable wilderness of shrubs, which fire itself is unable to destroy, the scrub rises as an unconquerable barrier to the advance of human culture. No less than the waterless desert, it has for many years presented a hindrance to the exploration of the interior of the continent, and even to connecting the flourishing settlements established at long distances along the coasts, by means of roads and thoroughfares. The characteristic form of the scrub is a soil without herbs or grass, thickly covered with intertwining shrubs, among which rise, here and there, a few trees. The height of the woody growths varies considerably; on the sand plains of South Australia the scrub is below six feet in height, while in other places it is often more than fifteen feet high. Plants of the most opposite families develope together, and look so like each other, that it is very difficult to distinguish them without seeing their blossom and fruit.

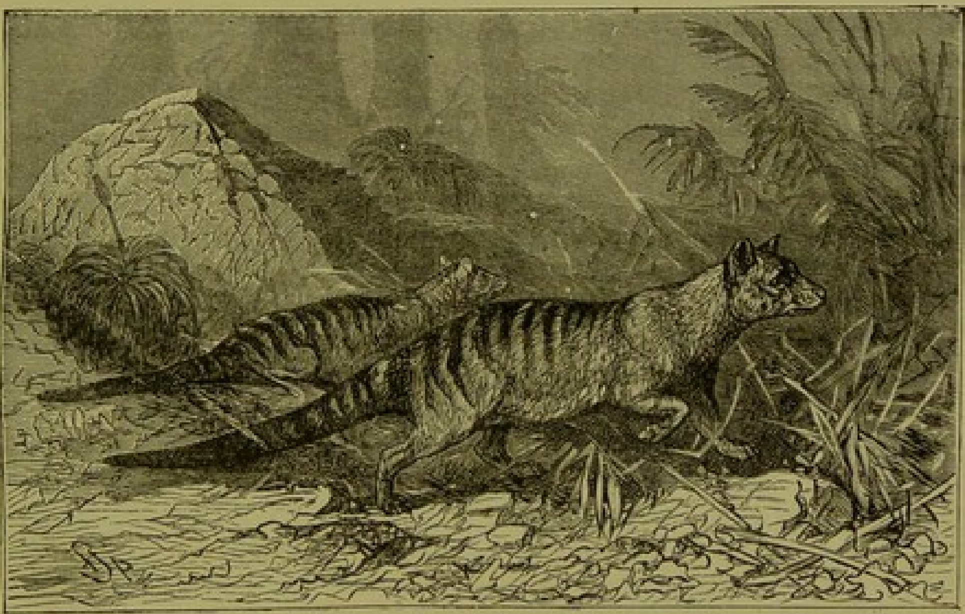
Bread-stuffs, corresponding to our corn or the American maize, are not possessed by Australia, unless we may make an exception in favour of the coola grass (*Panicum lævinode*), which is said to be cut, dried, and threshed like corn, both by the natives and the Europeans. Another edible plant, the nardo (*Marsilea hirsuta*), resembling a trefoil cryptogamous plant, bears berry-shaped fruits which are pleasant to the taste, but incapable of nourishing human life. It was on this fruit that Burke and Wills fed until they succumbed to hunger. Edible tubers are obtained from the *taro* or *kalo* plant (*Colocasia macrorhiza*), which is found in great quantities on the shores of rivers and in marshes. The natives must make use, not only of these plants, but of everything edible placed at their disposal by the vegetation round them; wild berries, the seeds of many leguminous plants, the fleshy leaves and fruits of the *Mesembryanthemeæ*, especially of the dwarf ice plant (*Mesembryanthemum præcox*), the leaves of chenopods, many mushrooms, the manna obtained from the leaves of the *Eucalyptus mannifera*, etc.

The flora of Tasmania, with regard to its species, is not essentially different from that of the mainland; isolated forms disappear, and others take their places; as the pine (*Dacrydium Franklinii*) and the celery pine (*Phyllocladus rhomboidalis*). Remarkable as a feature of the scenery are the tree-ferns, from twenty to thirty feet high, which lend their deep shadow to the luxuriant forests.

The animal world of Australia differs widely from that of the rest of the world, by the utter absence of land mammals, which are found in numbers in the Old World; the only two exceptions are bats and the equally cosmopolitan rodents. Of the latter, however, only one family is represented, that of rats and mice, and its representatives are all of small or medium size; an important fact if we wish to understand the character of the Australian fauna. In the place of apes, carnivora, and ungulata, which are found in great diversity and numbers in every other animal region, Australia possesses two new orders, or rather subdivisions, of marsupials and ornithorynchus found nowhere else on earth, except one single family of the marsupials in America. The Australian fauna therefore exhibits a character of great uniformity. The north has nowhere any exclusive forms deserving notice, but it possesses some tree marsupials, woolly phalangers (*cuscus*), probably natives of New Guinea. The east is indisputably the richest in animal forms, while the south and Tasmania are the poorest. Among the nearly 160 species of mammals, there are three varieties of ornithorynchus, 102 marsupials, twenty-three bats, and thirty-one rodents, together with the unique Australian dog dingo (*Canis dingo*), a carnivorous animal, probably not even a native of the country, but relapsed into a wild state.

Wonderfully framed, and adapted under the most widely differing forms to the most opposite conditions of life are the marsupials or pouch-bearing animals. Some are carnivorous, others herbivorous; some live on trees, and others on the ground. There are found among them insectivora and species which feed on roots, fruit, honey, leaves, and grass. Some resemble wolves, others marmots, weazels, squirrels, flying squirrels, dormice, and jerboas. They are divided into six different families, with about thirty genera, and they serve every purpose of natural economy answered in other parts of the world by very different groups of animals. Notwithstanding this, they all share in common the same peculiarities of structure and habit, which shew that they are members of one group, and possess no real kinship to those forms of the Old World which in their outward appearance they often closely resemble. The young are always born in a most imperfect condition: not only are they naked, blind, and deaf, but they have not even complete organs for the reception and digestion of food, and possess only stunted and undeveloped limbs. They are accordingly carried by the mother in a pouch until they are fully developed, and even then the pouch is often a secure place of refuge for the young animals when in danger or need of rest.

Among the chief representative of the order is the koala (*Phascolarctos cinereus*), or Australian bear, so called by its unmistakable resemblance in form, walk, and general appearance to a young bear. It is found only in the eastern districts. The wombats (*Phascolomys*), the representatives of the pouch-bearing rodents, are found in the south-east and in Tasmania. The flying marsupials are principally found in New South Wales; for instance, the flying phalanger (*petaurus, belideus sciureus*), and the flying mouse (*Acrobates pygmæus*). Tasmania is the home of the wolf or zebra dog (*Thylacinus cynocephalus*) and the Tasmanian devil (*Dasyurus ursinus*). The latter animal gave the first settlers endless trouble, and almost frustrated their attempts at poultry rearing. In Western Australia alone do we find the curious little honey-eater *tarsipes,* and the *peragalea,* or Australian rabbit. The singular insectivorous animal *Myrmecobius fascinatus,* or ant-eater, is found in the west and in the south. The majority of the animals which we have not yet had time to name have a wider area of distribution ; for instance, the marten, the native cats (*Dasyvirus vinerrinus*), the tafa, or *Phascogale pencillata,* the yellow mouse (*Antechinus flavipes*), the bandicoots, or pouched badgers (*Parameles*), the *Phalangista vulpina,* and above all the kangaroo family (*Macropodida*). Of the latter, besides the true kangaroos, with the giant kangaroo (*Macropus giganteus,* the old man of the settlers, *Macropus Billardierii Thedidis,* etc.), there are rock and hill kangaroos (*Petrogale pencillata* and *P. xanthopus*), and



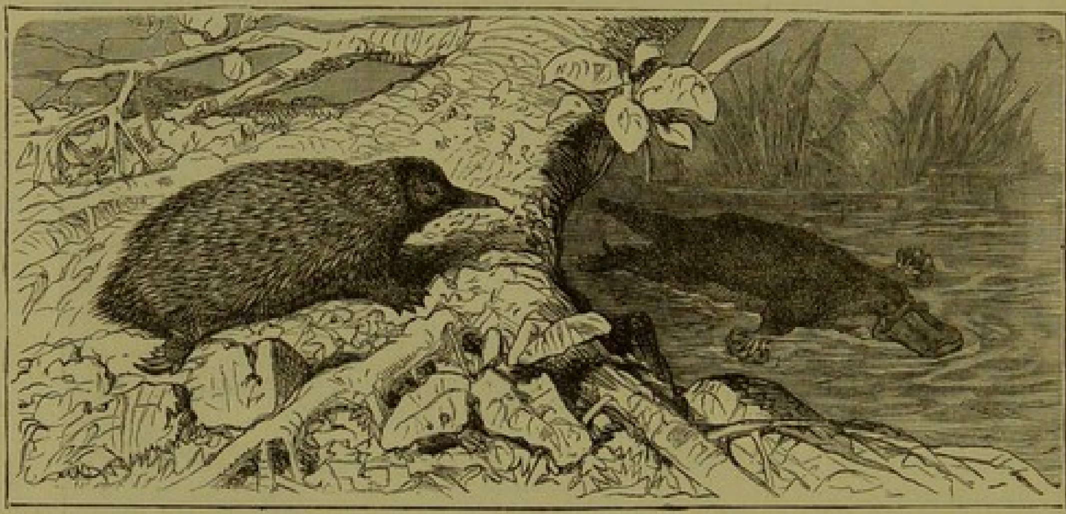
POUCH-BEARING WOLF (*Thylacinus cynocephalus*). Length, with tail, 60 inches.

the kangaroo rats (*Hypsiprymnus*), of which the largest is the oppossum rat (*H. pencillatus*). The giant kangaroos are scarcely to be found now in populous districts ; and even in the interior they are becoming scarcer in many places. Their favourite food is a kind of bunch grass, the so-called kangaroo grass (*Anthistiria Australis*) ; and although these animals have disappeared, or at least retreated from the coast to the heart of the interior, there are yet isolated places even among colonised districts where they are still to be met with in great numbers, wherever the kangaroo grass happens to grow, and then they generally appear in such numbers as to become a pest to the country by eating up all the herbage from the sheep.

The order *Ornithorhynchus* is represented by its rare and curious forms, *Ornithorhynchus paradoxus,* and two kinds of echidna, or porcupine ant-eaters (*Echidna hystrix* and *E. setosa*). The representatives of the bats and mice demand no special attention.

The Australian region is characterized almost as definitely by its birds as by its mammals. Specially striking is the entire absence of widely distributed families, the true finches and woodpeckers, vultures and pheasants, and equally remarkable is the absence from the predominant eastern groups of the bulbuls, or *pycnonotidæ*, the wattle-birds, and barbets. Nine families are peculiar to the region, or are found only just beyond the boundaries in a few species; these are the birds of paradise, the honey-suckers, lyre-birds, *atrichidæ*, or scrub-birds, cockatoos, grass-paroquets, lories, mound-birds, and cassowaries. Four more large families—the thick-headed shrike, flower-pecker, swallow shrike, and caterpillar shrike—are found well represented in some localities, and but feebly in others; the widely distributed weaver-birds, king-fishers, swallows, and pigeons, are unusually numerous and diversified; but of all Australian birds, the most peculiar and the most characteristic are the honey-eaters, or *meliphagidæ*.

Continental Australia, including Tasmania, possesses nearly 630 species of birds, among which are 485 land birds. Not more than a twentieth part of these birds are found anywhere else, so that this sub-region exhibits a higher percentage of exclusive species than any other country in the world. The parrot tribe is very richly represented; while the woodpeckers are compara-



Ant-Hedgehog (*Echidna hystrix*, *Ornithorhynchus paradoxus*). Length, 18 to 20 inches.

tively poor, and the pigeons scanty, in comparison to the numbers found in the Austro-Malayan region. The birds are distributed with tolerable evenness throughout the whole continent; comparatively few genera being restricted to special localities.

The largest native bird is the emu (*Dromæus Novæ Hollandiæ*), belonging to the family of the cassowaries, and standing six feet high. Whoever desires now to catch a glimpse of the once common emu in his native land must penetrate to the remotest corners of Tasmania or to the plains of Victoria and Central Australia, where they are said to be still found in great numbers. Second to the emu in size ranks the giant stork (*Mycteria Australis*), or yariboo of the colonist. Characteristic also is the black swan *cygnus atratus*, whose large, delicately flavoured eggs are brought into the market from the Murray in great numbers, especially about Christmas-time.

The parrots understand perfectly the art of attracting attention. It is impossible to describe the enchanting effect of the spectacle presented by these beautiful birds, especially the vivid scarlet parrots, flitting to and fro among the silvery foliage of the acacias. Nothing could exceed the contrast of their gorgeous plumage with the delicate leaves. Morning and evening countless numbers of them are seen flying away at a great height overhead, uttering as they fly a most intolerable screeching.

Among the cockatoos, the most beautiful and the gentlest are the Inca cockatoo (*Plictolophus leadbeaterii*), the scarlet crested (*Calyptorhynchus galeatus*), and the black raven cockatoo (*C. Banksii*). The most singular is the long-billed *Licmetis nasica*, and the most different from the rest, the corella, or *Callipsithacus Novæ Hollandiæ*. They all live in large companies, preferring the sheltering leafy roof of lofty trees, where they amuse themselves with shrieking, climbing, and flying about; every now and then making a raid upon the neighbouring maize fields, to treat themselves to the sweet, floury grains. Among all the parrots which we keep in our cages, the native little *Melopsittacus undulatus* claims the first rank; next in our estimation comes the Rosella (*Platycercus eximius*), also a native bird, and the rainbow-coloured lory (*Trichoglossus Novæ Hollandiæ*), which is the glory of the eucalyptus forests. Besides these, there are numerous other parrots and paroquets of the most brilliant colouring, all of which are hated and pursued by the careful farmer as pests.

Many of the smaller birds are also distinguished by their vivid colours; among which we may mention the honey-suckers, or bush-tongued birds, belonging almost exclusively to Australia, and represented by about 190 species; the chocolate and scarlet-coloured *Myzomela erythrocephala*, the flower bird (*Melichæra mellivora*), and the monk bird, or leather-head (*Tropidorhynchus corniculatus*). The latter is found throughout the whole continent, and makes itself very conspicuous by its singularly noisy calls, which sound to the colonists like "poor soldier," "four o'clock," etc., and so have become names for the bird itself.

The family of the cuckoos is represented by the giant cuckoo (*Scythrops Novæ Hollandiæ*), a bird two feet in height; that of the halcyons or kingfishers by the *Paralcyon gigas*, a giant kingfisher, twenty inches high. The latter bird is also known as the laughing jackass, and is the most absurdly impertinent creature that can be imagined. Very inquisitive, he begins as soon as his curiosity is satisfied to indulge in a low chuckling laugh, which grows louder and louder, until at last he breaks out into peal after peal of resonant, shrill, mocking, truly diabolical laughter, in which his feathered acquaintances in the neighbourhood take part; so that the lonely traveller might fancy the solitary depths of the forests were haunted, if he did not know perfectly well that it was only the tricksy harmless "laughing jackass," perched among the branches before him, and leading the infernal concert of his kindred birds.

Among the most remarkable birds are the glossy starlings (*Ptilonorhynchus holisericeus*), belonging to the starling tribe, and the ruff birds, of which the best known is the *Chlamydodera maculata*. Gould relates that, in his journey through the cedar bushwood, he came upon several of the bowers built by the glossy starlings. They were generally erected in the loneliest parts of the forest, under the shelter of overhanging boughs, and always resting on the ground. The foundation was made of closely interwoven twigs, and the bower itself was built of the finer and more pliant sprigs and branches. The materials were so arranged that the points and forks of the branches met above, leaving an entrance on either side. The bowers were adorned by the addition of all kinds of bright-coloured materials, the gay tail feathers of paroquets, opaline mussel shells, snail shells, pebbles, bleached bones, etc.

The feathers were stuck in among the twigs, and the bones and shells arranged round the entrance.

The brush turkeys, of which we have already spoken in our chapter on Celebes and the Moluccas, are represented by the *Tallegalla Lathami*, the jungle fowl (*Megapodius tumulus*) and the leipoa (*Leipoa ocellata*). Amid the tangled thickets of the valleys of New South Wales is found the lyre bird (*Menura superba*); the falcon shrike (*Falcunculus frontatus*) also belongs to the south; one of the most frequently observed birds of this district, finally, is the *podargus humeralis*, or frog-mouthed goatsucker. There is no lack of pigeons (long-tailed pigeons, *oxyphaps lophotes*, *phaps chalcoptera*, etc.), quails, bustards, herons, eagles, and stormy petrels on the coast. On the rivers and standing waters are numbers of different species of aquatic and marsh birds. The absence of singing birds is greatly to be regretted; but the docile flute bird (*Gymnorhina tibicen*) may be regarded as one, as the colonists gladly admit; it belongs to the species of whistling crows, and its not unmelodious notes cheer and rejoice the lonely wanderer in the bush.

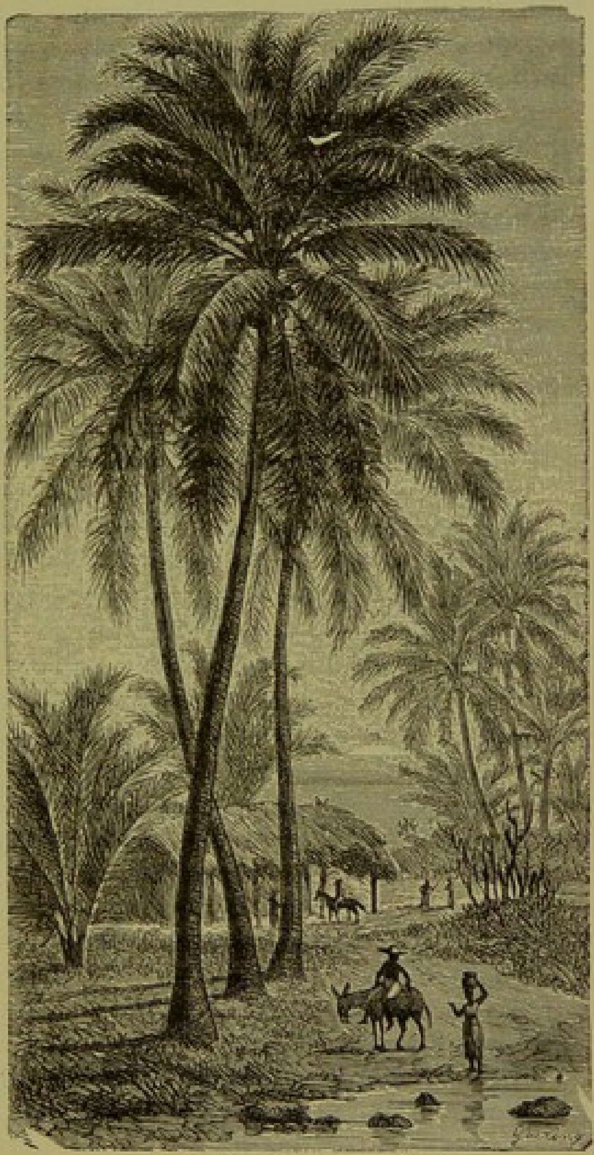
Australia is rich in snakes, and nearly two-thirds of them belong to the family of poisonous adders (*elapidæ*). In Tasmania there are only three kinds, all of which are venomous; eight of the twelve species found in Victoria are poisonous. West and South Australia have fifteen species each; among which ten of the western snakes and thirteen of the southern are poisonous. New South Wales has thirty-one kinds, of which twenty are poisonous and subtropical. Queensland has forty-two species, of which twenty-eight are poisonous; so that although there are neither vipers nor rattlesnakes, there is perhaps a larger proportion of poisonous to harmless snakes in Australia than in any other part of the world. Among the most dangerous kinds must be reckoned the black viper (*Pseudechis porphyreus*), the yellow viper (*Alecto curta*) which measures three to five feet long, and the deadly or thorn viper (*Acanthophis antarcticus*), two to three feet long. Crocodiles (*Crocodilus biporcatus*) are found in all rivers within the tropics. The 140 species of lizards are, with one or two exceptions, all of them exclusive, and nearly all belong to the gekkoes and skinks. A member of the agama tribe is the so-called prickly devil (*Molochus horridus*), and there are three varieties of fresh-water or river turtles. Frogs and toads are numerous, but tailed amphibia are not known. Most of the fish species are exclusive, and belong to the most widely separated families, but the carp and toothed carp tribes are not represented. The lung-breathing fish barramuda (*Ceratodus Fosteri*) deserves especial mention.

Australia is poor in butterflies, except in the tropical regions, where the beautiful green *ornithoptera* are found. Beetles, especially long-horned boring beetles and shining beetles, are more fully represented. The lower animals are as yet imperfectly studied; but three hundred kinds of snails are already classified.

The Islands of the Pacific Ocean.

By this title it is not now meant to include all the islands washed by the waters of the Pacific; on the contrary, it is intended to exclude all those which, for any reason whatever, belong to Asia or to America. We have already directed the attention of our readers to the vagueness and uncertainty of these divisions, according as they are based upon the characteristics of the flora or fauna; and they become still more variable when, as must necessarily be the case in geography, the different races are also taken into account in order to form a true geographical whole, or, as Ritter expresses it, a "land individuality."

Of the numerous archipelagoes of the Pacific, one, New Zealand, lies in the temperate zone, a circumstance by which it is placed, with reference to its flora and fauna, in different conditions from the remaining islands. The climate and distribution of the seasons in the islands of the tropic zones depend essentially upon the prevailing atmospheric currents; and in the tracts of the ocean which flow round the islands of which we have now to speak we find a gradual transition from the monsoon to the trade-wind. To the south of the equator, for instance, in the eastern Polynesian archipelago, the south-east trade-wind begins in April, and lasts, accompanied by fine weather, regularly, and without a break, until the following January, from which time until March it is exchanged for the storm and rain-laden west winds.

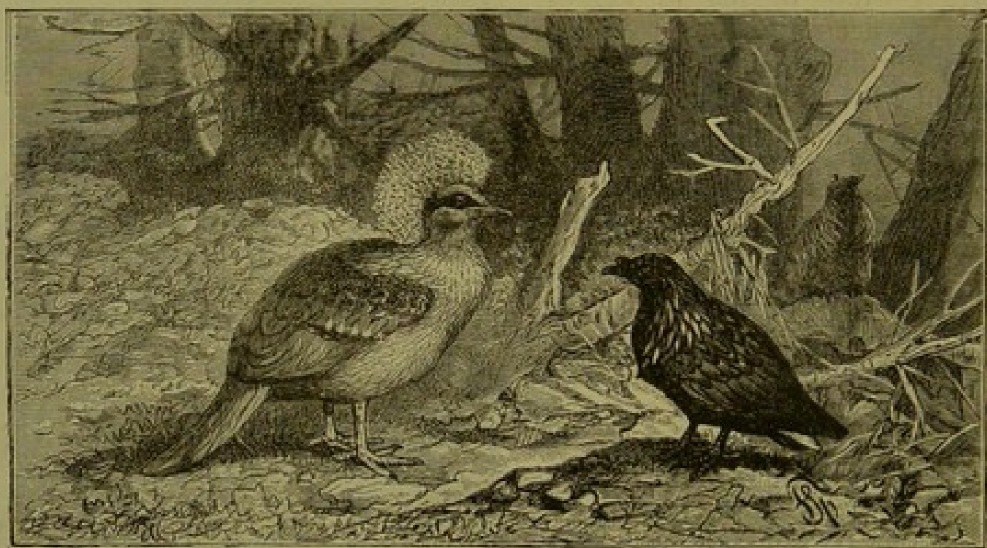


Cocoa Palm (*Cocos nucifera*).

A closer examination of the separate archipelagoes shews that toward the east the flora becomes persistently poorer and simpler, that the solitary instances of higher plants gradually disappear, and the vegetation shrivels up as it were, and dwindles; although the Indian character of the plant forms remains still so far predominant, that in Waihou, or Easter Island, the most easterly of all the islands, being situated 120° east of the Moluccas, and 75° from New Zealand, there is hardly a plant to be found which does not belong either to the Indian or New Zealand flora.

With reference to the distribution of land animals, we find the same diminution eastward, as characterised the plant world, but there is also a close connection with the Australian fauna. The island world is extremely poor in mammals; only fifty species are known as yet, and of these one-third belong to New Guinea. They are moreover distinguished neither by size nor peculiarity of formation. Apes and ruminants are altogether unknown; the greatest number of species belong to bats and marsupials; besides which there are a few rodents, carnivora, and pachydermata. Carnivora and bats are found in the northern hemisphere, as far as Hawaii; in the southern, no farther east than Samoa and Tonga; the marsupials belong almost all of them to New Guinea, and extend no farther eastward than to Solomon's Islands. Similarly the wild pachydermata, for instance, the Papuan pig (*Sus Papuensis*), is not found beyond Melanesia; while the rodents, especially rats, are found everywhere, even on the small islands of the lagoons, and as far as Easter Island, and so form the only mammal tribe common to all the archipelagoes, if we assume that pigs and dogs were imported, and are not natives of the islands.

Birds are, generally speaking, much more numerous and more diversified than the mammals; but, like them, gradually decrease toward the east. Carnivorous birds are proportionately scarce; falcons are found chiefly in New Guinea, and farther eastward, as far as Feejee, while single species of owls are found in Hawaii and Tonga. More numerous and more widely distributed, while distinguished in many cases by extraordinary beauty and vivid colouring, are the different species of the sparrow tribe, especially the birds of paradise. These birds are met with chiefly in New Guinea, which contains also the most beautiful specimens of certain species; but some species extend as



CRESTED PIGEON.

far as Hawaii and Tuamotu. Much more important are the climbing birds and pigeon tribe. The former are represented by the parrot family, which is extremely numerous, and contains probably more than 120 varieties, half of which belong to New Guinea, while solitary species are met with as far distant as Hawaii, the Marquesas, and Tuamotu. Pigeons, the second of the great groups which impart to the bird tribe of these islands their peculiar character, are found in more than 100 varieties, half of which inhabit New Guinea, and some extend to the archipelago of Tuamotu. Especially remarkable are the widely distributed crested pigeons (*Callœnas nicobarica*), and the tooth-billed pigeons (*Didunculus strigirostris*), found only in the Sailor Islands. Of the wading birds, the distribution of which corresponds with that of the pigeon tribe, some, like the African ostrich, the nandu, or American ostrich, and the Australian emu, are distinguished by the shortness and imperfection of their wings; but are now evidently in process of dying out, some species having already entirely disappeared, as the cassowary from New Guinea and New Britain, the apteryx, and the great land rail from New Zealand, the bush turkeys from New Guinea, etc.

Land reptiles and amphibia are scarce. Snakes are only found in certain varieties, and, as it seems, extend no farther southward than the New Hebrides, and no farther eastward than Tonga. Frogs are still more seldom found; with the exception of a few kinds in New Guinea, which also possesses the largest number of snakes, there are only a few in the Feejee Islands, New Hebrides, and New Zealand. Lizards, on the contrary, are very widely distributed, and are even found on the small lagoon islands, and as far as Tuamotu, though they are more numerous in New Guinea and the adjoining Melanesian archipelago. One species of crocodile (*Crocodilus biporcatus*) extends to the Samoan Islands and the Carolinas. The distribution of insect life is very peculiar. It is natural to expect that they should be found in abundance in islands situated within the tropic zone, and possessing such a luxuriant vegetation; and such indeed is the case as far as regards New Guinea and the rest of northern Melanesia, but the archipelagoes of southern Melanesia and New Zealand are far less rich; the Feejee Islands are distinguished rather by the diversity than the number of species, and all the other southern islands and the remaining archipelagoes of the northern hemisphere are distinctly poor in insects. Even the distribution of the separate orders is a singular one. While in New Guinea, New Britain, New Caledonia, and New Zealand, beetles predominate, although a great number of butterflies are also found in the same islands, the latter insects exceed all others in numbers in the remaining parts of the archipelago, increasing in number as we advance eastward; they also extend as far as Tuamotu. Flies and mosquitoes abound everywhere. The distribution of marine animals is altogether different from that of the land fauna; for, in the first place, the former betray a closer connection with Indian forms; and secondly, there is with them no question of anything like a decrease in numbers toward the east. Besides this, a foreign element is introduced among them by the admixture with tropical forms of such as belong essentially to the northern and southern temperate zones, and even to the arctic regions; a circumstance which occurs also on the Australian coasts, and is favoured by the direction of the winds and ocean currents.

New Guinea, perhaps the largest island in the world, is even yet singularly little known. It is apparently covered with luxuriant forests; at least, the small patches of land cultivated by the natives are thrown into comparative insignificance by the extent of the forest land. Almost all that is known as yet of its natural productions comes from the north-western peninsula, and from a few islands lying round it, which do not occupy one-tenth of the area of the whole island, and are cut off from it in such a manner that their flora and fauna may easily be quite distinct; indeed, the island is said by Wallace to be the only region in which new life forms might yet be found. New Guinea is poor in mammals, a few bats, the Papuan pig, and about a dozen marsupials being all that are known at the present time; among the latter are the tree kangaroo (*Dendrolagus ursinus*) and a flying opossum (*Petaurus*). The birds present the most striking contrast to the mammals, as they are very numerous, and exhibit more new, rare, and beautiful forms than any other island in the world. Of the eighteen varieties of birds of paradise at present known, eleven are found in New Guinea, six of them being exclusive forms. Of the thirty kinds of parrots, the large black cockatoo (arara cockatoo, *Microglossus aterrimus*) and the little dwarf cockatoo (*Nasiterna pygmæa*) represent respectively the giant and dwarf of the species, and the great diversity of the brilliantly coloured lories is unparalleled elsewhere.

The pigeon tribe is represented in nearly forty varieties, one of them being the crowned pigeon (*Goura coronata*). The connection between the fauna of New Guinea and Australia is very marked. It is most perceptible in the mammals by the preponderance of marsupials and the all but complete exclusion of all other land forms. Among birds it is less striking, though still clearly traceable; for almost all the remarkable forms of the Old World which are unknown in Australia are equally unknown in New Guinea; such as pheasants, sand-grouse, vultures, and woodpeckers; while cockatoos, broad-tailed parrots, podarginæ, cassowaries, and lastly the great families of the honey-feeders (*Nectarinidæ*), and talegalls, or mound-birds (*Talegallinæ*), etc., altogether no less than twenty-four species of land birds, are common to both countries, and entirely restricted to them.

BIRDS OF PARADISE. 1. Birds of the Gods (*Paradisea Apoda*); 2. Royal Birds of Paradise (*Cicinnurus regia*); 3. *Parotia sefilata.*

Although the archipelago of the Sandwich Islands lies on both sides of the tropics, Hawaii possesses a rainy season of five months' duration, from May to September. Along the coast both the rainfall and the flora are insignificant; but already, at a few miles inland, an increase of moisture, with the natural result of lasting verdure, is perceived. The greatest part of the island is clothed with luxuriant vegetation; plantations of cocoa palms and bread-fruit alternate with fields of sugar-cane, and a belt of forest encircles the volcanoes above the cultivated lowlands. The total amount of hitherto found flowering plants amounts to no less than 600 kinds, 370 of which are exclusive;

about 130 species of ferns and other cellular cryptogamia. Almost all the native plants are found in the forest region, only about twenty species appearing elsewhere. The prevalent forest tree, the koa (*Acacia koa*), spreads its leafy crest above a stunted copse of evergreen undergrowth. Among the trees which accompany the koa are a few Australian species, one of which, the red sandal-wood (*Santalum*), has already become scarce by the exportation of its fragrant wood. On the volcanic mountain, Manna Kea, more than 12,750 feet above the level of the sea, the solitary growth of the manati tree, a leguminous plant twenty to thirty feet high, is found up to 9,450 feet; while on the Manna Lod, which is almost as high, but coated with lava, nothing is found at the height of 5,260 feet above the sea, except a solitary moss. It is of special interest to notice that on the higher peaks of the island groups nearly thirty species of plants belonging to the arctic and northern temperate zones have been found. Some of them are found also in Australia and New Zealand; others are not, such as vetch, strawberry, aster, bilberry, and pines. Their presence seems to indicate clearly a former approach of the Sandwich Islands to the America of the temperate zone, although the absence of all American vertebrate animals proves conclusively that an actual connection of the two countries never existed. Mammals are absent, land birds are found in the archipelago only in eleven families, with eighteen species, among which are nine exclusive kinds, while water-fowl and waders are represented in all cases by widely distributed families. Land snails (*Achatinella*) are found in nearly 300 genera.

The flora of the Feejee Islands, the largest of the tropical island groups, by no means exhibits the same independent character, as distinguished from the mainland, that we find in the Sandwich Islands. The Feejee group is clothed up to its basaltic peaks with the most luxuriant tropical vegetation. The forest, with its leafy tree crests, allows but little undergrowth to appear; in the higher region (above 1,875 feet), where it becomes clearer, the ferns are more numerous, and the tree trunks are draped more closely with epiphytæ and lianas (climbing pandanus, *Freycinetia*). The contrast is strongly marked between the mountain slopes turned toward, or from, the trade-wind. In the former there is but little difference between the wet and dry seasons, and they are accordingly richly wooded; palms flourish, together with tree-fern, bamboos, aromatic sedges, and atmospheric orchids. On the savannah soil of the seaside, which is visited by less moisture, there rise from the grass and ferns scattered screw-pines and she-oaks, or the few trees by which the Australian type passes over also to the South Sea Islands (*Acacia laurifolia, metrosideros*); on a higher level, however, the tropical forest growth, owing to irrigation, obtains the preponderance even here. Rather more than half of the seven hundred flowering plants are exclusive; a quarter are Indian, and the rest consist of entirely tropical or pacific varieties.

New Caledonia possesses a purely Australian character, while having several exclusive families; the forests have no undergrowth, and on a dry grassy plain, melaleuca or cajeput trees are seen at wide intervals. The small group of Norfolk Islands is distinguished by its *Araucaria excelsa*, one of the most beautiful tree forms in the world, from 150 to 180 feet in height; its screw-pines (*Freycinetia*); a palm (*Areca Baneri*), and two tree-ferns (*Alsaphila* and *Cyathea*); and consequently is more nearly allied to New Zealand than to Australia. To the former country also it is indebted for its characteristic liliaceous growth, the New Zealand flax (*Phormium tenax*). Not much need be said of this island group, although it certainly lays claim to a few exclusive forms of land birds.

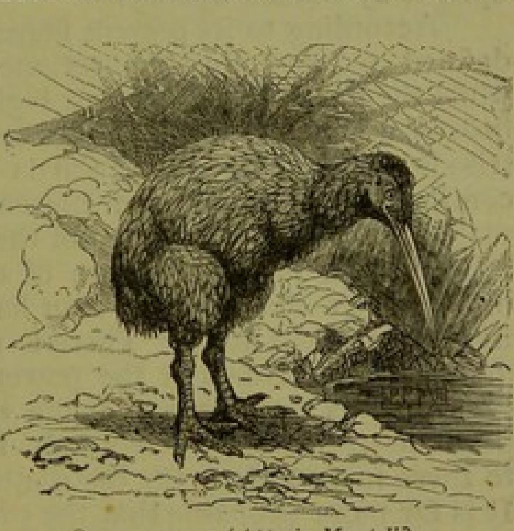
NEW ZEALAND.

With regard to Australia, which is little more than 900 miles distant, New Zealand holds the same position as the antarctic forest region of South America does to the Pampas, or as a wooded and fertile corn-growing country does to a barren steppe, where nothing prospers but cattle-breeding. The forests of New Zealand, in which an impenetrable thicket of undergrowth is formed by ferns and lianas (*Freycinetiæ, Banksii, ripogonium, rubus, clematis, passiflora*, and *sicyas*), bear the impress of a climate akin to that of the tropics. Their noble timber trees enable them in some places to surpass the tropical woods in height and grandeur. Among these lofty trees is the kauri fir (*Dammara Australis*), now, unfortunately, decreasing in numbers; it is restricted to the northern part of the island, and only found there in isolated plantations. Some of its colossal trunks, perfect columns of wood, measure twelve feet in diameter, and have an unbroken shaft of 120 feet below the lowest branch. Besides the kauri, we find other characteristic forms, which, by their massive growth or picturesque grouping, lend a peculiar character to the scenery, such as the Kahikatea fir (*Podocarpus dacrydioides*), which is often 120 feet high, and the black birch (*Fagus fusca*), found in the south of the island. The ordinary high woods of New Zealand are all of them composite, and appear as a monotonous mass of brownish green, without any distinctive physiognomical character. On entering the forest, it is the ferns which at first arrest the attention; magnificent tree-fern with lofty trunks, thirty feet high, and regularly marked, above which extend the elegant crowns of foliage (*Dicksonia* and *Cyathea, hymenophyllæ* and *polypodi*), in the most widely differing varieties, covering with rich luxuriance the trunks of the forest trees, and the curious fern form, the kidney fern (*Trichomanes reniforme*): ferns in the boughs and branches of the trees, ferns on the ground —in short, ferns of every variety, and in countless numbers.

The different kinds of conifer forms the crowning beauty of the woods; *Podocarpus totara* and *P. spicata* are found in every forest. The *Dacrydium cupressinum* is distinguished by drooping leaves and branches, and the *Phyllocladus trichomanoides* by its leaves, which resemble a sprig of parsley. Near to these rise the lofty *Knightia excelsa*, a tree recalling the poplar, and one of the two *protaceæ* of New Zealand, and the hinau tree (*elæcarpus hinau*), whose fruit is eagerly sought by the parrot tribe, while the bark is used by the natives for dye. In some places, also, the *Edwardsia microphylla*, with its gorgeous yellow papilionaceous flowers, grows to an imposing height. Among some of the largest forest trees are several representatives of the myrtle and laurel tribes, the principal being the rata tree (*Metrosideros robusta*), the trunk of which is often between thirty and forty feet in circumference, and covered with parasites of every kind, while its crown bears clusters of scarlet blossoms. The undergrowth is composed of shrubs and bushes of widely differing kinds, especially varieties of *panax* and *aralia*, above which the graceful Nikau palm (*Rhopalostylis sapida*), the only representative of its kind in New Zealand, raises its fresh green crown with picturesque effect. Among the liliaceous trees (grass tree, cabbage palm, *cordyline*), the trunk decreases in height, until beyond the limits of the forest it disappears altogether, and is lost in the wide, leafy rosette of the New Zealand flax (*Phormium tenax*).

Along the open mountain slopes, and on the barren plains which abound on the eastern side of the island, bushes of *Leptospermiæ*, six feet in height, are the prevailing shrubs, and the crucifer tribe (*Pomaderris*), or the impenetrable fern thickets of the *Pteris esculenta*, also six feet high, which is generally considered to be a climatic variety of the European eagle fern; but, while the latter is useless, the *Pteris esculenta* is valuable for its great amount of nutritious matter. The ferns here replace the grasses, and alternate with shrubs in covering wide stretches of open country. No land in the whole world can equal New Zealand in its massive fern growth; and its vegetation resembles most closely the oldest floras of the prehistoric world, among whose remains the cryptogamous plants prevail. Here the flora, too, is the home of the veronica shrubs, one of the few genera of which includes a greater variety of species. Grasses and leguminous plants are everywhere feebly represented, and annual herbs are almost entirely wanting. But the original condition of each island seems to have been forest; for the resin of the kauri pine is dug up out of the fern undergrowth, and it is assumed that that land must have been cleared by human agency, probably, as Darwin suggests, by the natives who, in past ages, fired the forests to give room to the ferns, from which they lived. Of the nearly one thousand cryptogamous plants, 72 per cent. are exclusive.

The fauna of New Zealand is almost more remarkable than its flora; so much so, that, together with a few smaller islands, it forms a zoological sub-region of itself. The only mammals known are two peculiar bats. A wood rat is said to have been at one time very numerously distributed over both the islands, and to have been eaten by the natives; but it is doubtful whether it was not merely an immigrant; and the seals are widely distributed antarctic forms which have no geographical importance. Of the thirty-four kinds of land birds, including fifty-seven species, sixteen are exclusive, and so are five of the eighty-eight species of aquatic and wading birds; the others give to the fauna an Australian character. One of the most pleasing bird forms is the so-called *Tui* (*Perosthemadera Novæ Zeelandiæ*), so much admired for its tuneful song.



OSTRICH-SNIPE (*Apteryx Mantelli*).
Height, 32 to 34 inches.

Special notice is deserved by the curious little ostrich snipe (*Apteryx*), and the gigantic moa (*Dinornis* and *Palapteryx*), which has only recently become extinct. Owen estimates the height of this bird at ten feet eight inches, and Thomson at fourteen feet two inches. Among creeping things, the scarcity of frogs and the entire absence of snakes and turtles is remarkable. Lizards are represented by twelve harmless kinds, the most interesting being the *Hatteria punctata*, which lives in holes, and is found in the little islands of the north-east coasts. With respect to its construction, this creature stands between the lizard and the crocodile, and at the same time exhibits a bird-like character in the shape of the ribs. It forms a special order of reptiles (*Rhynchocephalina*), is quite isolated from all other members of the class, and probably is a slightly altered representative of an old primeval form. The bays and coasts are unusually rich in fish, about one hundred kinds being known. The fresh-water lakes and rivers, on the contrary, are very poor, unless the unexplored mountain streams of the south of the island prove to contain many new forms. Hochstetter found nothing but eels; but the weight of some of them was very remarkable, amounting to more than fifty pounds.

CHAPTER VI.

ORGANIC LIFE OF EUROPE.

WITH reference to its organic life, Europe by no means represents an independent whole; and if we have nevertheless separated it from its firmly consolidated union with Asia and Africa, in order to end our wanderings in our own continent, we have done so because it has been, above all quarters of the globe, altered and modified by the hand of men, and at least in its principal civilised countries bears almost exclusively the aspect impressed upon it by human agency.

According to its present fauna and flora, Europe is divided into two well-defined regions, the Mediterranean region and the large remainder; but while the latter forms one zoological sub-region, it is shared between three botanical regions; and the question may well present itself, whether the distribution of plants and animals really corresponds so imperfectly in our continent, or whether the present accepted divisions have a corresponding reality in fact. Our survey of the world has taught us that the plant world represents a faithful picture of climatic conditions; and we have shewn in an earlier chapter that man has also borne a part in contributing to the flora its present form. There is no essential difference in this respect in the animal world, although the powers of movement possessed by its members often effaces the national fauna of separate countries, and prevents its independence from being recognised. It would nevertheless be erroneous to ascribe to these factors alone the distribution of organisms in their present condition. It is far more probable that the present state of things has arisen gradually, as has been shewn by Engler with reference to plants; and been developed geologically, so that as the formation of the continent has demonstrably changed, especially since the tertiary period, its organic life and more particularly with respect to its geographical portion, must have flowed into other courses. Thus the present home of many plants and animals is not their place of birth, but only their region of preservation. There are, however, no sharply defined limits between the separate botanical or zoological regions; on the contrary, elements encroach one upon the other, and the measure of the encroachment is determined by the geological development of the now separated regions. This geological point of view, to which zoological geography is indebted for so many valuable results, has only been applied within very recent times to the geography of plants, and this may be the very reason why the boundaries of the animal and vegetable kingdoms shew such a want of agreement; at any rate, we may expect, and perhaps at a very early date, to see modifications and alterations introduced into our present classifications.

The Mediterranean Region.

The chief peculiarities of the climate of the Mediterranean region are the rainlessness of the summer and the mildness of the winter.

In this region the atmospheric rainfall is not, as in the north, distributed throughout the whole year, but the hot summer is rainless. As the sun approaches the northern tropical circle, and the hottest zone of the earth follows its course, the trade-wind also advances into higher latitudes; and the African desert, with its barren plains over-heated in the summer months, produces the north-east winds, which, absorbing heat as they advance, create the rainless season of Southern Europe. The farther southward we advance, the slighter is the amount of the summer rainfall, and the longer the period of drought. The latter extends in Florence over one month, in Rome two, Naples three, Sicily four to four and a half, Malta six months. The Peloponnesus has a rainless season of four to five months. In order to appreciate duly the effect of the drought, it is necessary to pay careful heed to the power of evaporation, which is, for instance, three times as great in Rome as it is in Germany. Finally, the rainfall is distributed over a comparatively short period. Fine rain, such as we have in England, is rarely seen; the downpour descends generally with tropical violence, causing the irregular watermark of the rivers which appear in summer as dry gravel beds where the eye searches in vain for a thread of water, and in winter as mighty streams overflowing their banks and the adjacent country.

The winter is far milder than on this side of the Alps, while the summer is not proportionately warmer. Although the northern sun does not stand so high in the sky, this position is in some measure neutralised by the greater length of the days; while in winter the longer nights work in the same direction as the lower position of the sun, and increase the cold. The difference of temperature between January and July amounts in Moscow to 55°, in Berlin to 38°, in Rome to 30°, and in Palermo only to 25°. The lowest temperature recorded in Rome is 22·5° F. The high temperature prevents anything like a fall of snow in the plains. There are in Rome only one or two snowy days throughout the year, and the snow either melts as it falls, or does not lie on the ground. An old resident of Palermo gave it as his opinion that it would take ten years to collect a handful of snow. In Athens, a few years ago, a fall of snow aroused the greatest astonishment; and indeed the Athenians did not recover from their amazement until they saw what the snow was good for; and young and old set about making snowballs until the phenomenon melted away.

By the surface configuration of the large territory extending from the east, westward, the climate is subjected to manifold changes, and it is just this blending of different climates, shewing itself in the products of the separate districts, which has chiefly contributed to the ancient culture, and to the manifest separate national developments of the Mediterranean countries.

One result of these climatic peculiarities is, that in the south, organic life assumes other forms than those with which we are familiar. The true Mediterranean flora is characterized by a series of evergreen trees, shrubs, and some of them with pliant and leathery, others with stiff parchment leaves, preserved from any great evaporation. Laurel and myrtle, then the olive, the most important cultivated plant, are well-known types of this flora, distinguished by the rich deep green of their glossy foliage. Plants so protected cannot be injured by the summer sun, while annual grasses and herbs are scorched up; so that the plains which during the whole winter were clothed in the most luxuriant green, appear in July and August as bare, parched steppes. In October, when the first autumn rains fall, nature awakes, grasses, shrubs, and trees begin to shoot, the earth is again covered with a green carpet, and flowers spring up on every side. Owing to its high temperature, the winter occasions only an almost imperceptible interruption, if any at all, to the development of plants; and the winter sleep to which our English plants are subject is replaced by a summer sleep.

It will be naturally taken for granted that the relation of man to the seasons and the heavenly bodies on which they depend must be different from our own. While the ancient Germans looked up to the sun as a goddess, mild and beneficent, and connected the moon with the ringing frosts of cloudless winter nights, the dwellers in the Mediterranean lands looked upon the moon as the type of all that was womanly, the gentle goddess of the night standing by all creatures in their uttermost distress. The nameless magic of the moonlit nights of the south, rivalling the brightness of day, can yet be felt and understood from the representations of mythology; while Helios, the sun god, is the harsh, stern deity, whose arrows deal death and destruction. Before them fade the flowerets of the field and the life of man.

SPRAY OF OLIVE.

Italy, geographically speaking, holds a medium position with reference to the other parts of this region. Its climate is equally withdrawn from all extremes, but it may be divided, according to its yearly isothermal lines, into three principal zones. The first, with an average temperature of 55·5° to 57°, comprises the north, or basin of the Po. As this division forms the geographical transition from the Mediterranean world to the interior of the continent, it exhibits likewise a climatic transition land. The climate of Padua, with its summer rains, and extremes of heat and cold, approaches much more closely the continental than the Mediterranean character; it has the summer temperature of Sicily, with a colder winter than Paris or Hamburgh. The second zone is that of the equinoctial rains, in which the principal rainfall descends in spring and autumn. The average yearly temperature is 59·2° to 60·3°. To this division belongs most of the Apennine peninsula, and here the olive, the true representative of antique and Mediterranean culture, asserts her right to the soil. The transition from the first zone to the second is abrupt and strongly marked. Bologna has a hotter summer than Florence, but a winter colder by four and a half degrees. The third and last zone has an average temperature of 64° to 67°, and may be termed the zone of the winter rains, as the greater part of the rainfall follows the lowest position of the sun. The vegetation is distinguished by the cultivated trees obtained from the Indian peninsula, and by orange and lemon trees. This zone includes the south-west of Sardinia, all Sicily, and a small part of the continent. Naples lies within its limits, and then the boundary swerves southward, over the Apulian peninsula. The difference between this zone and the preceding is strongly marked. In the minds and feelings of the ancients it held a prominent and unique position. Thither were they allured by a perpetual spring, thither they fled for shelter from the inclemency of a Roman sky; while history marked the difference between them in more deeply traced and more important lines. The colonies of the Hellenes were exclusively restricted to the third zone; within its limits foreign culture found a home and centre of diffusion. The three climatic sections are therefore expressed in three historical phases: the north, or colonized land conquered by the Romans; the centre, or home of the old Italian races; and lastly, the Hellenized south.

Both the climate and history of Italy are affected as actively by the vertical as by the horizontal divisions of Italy. It is a mountainous land, and at about the height of 450 feet above the sea level the yearly temperature is lowered by nearly two degrees. We find, therefore, three superimposed zones, a sea, a hill, and a mountain zone. The first occupies about one-tenth of the whole area, including the Etruscan, Latin, Campanian, Apulian, and other plains, which in ancient times were the seat of political, civil, and social development. It alone possesses the advantages of the Mediterranean climate without reserve. The hill zone, which comprises about a third of the peninsula, only enjoys it in part; for the olive and evergreen region never rises above the height of 1,100 feet; vine and wheat scarcely above 3,000 feet. Fully half of the country has the winter, and with it much of the vegetation, of Central Europe, whose flora at this point (1,100 to 5,640 feet) is repeated in chestnut, oak, and beech woods. It is true that it would be vain to look for the rich meadows of the Alps. The Apennines combine the shadow sides of the north and the Mediterranean climates, possessing the wintry cold of the one with the summer drought of the other. The configuration of Italy explains the course of its history. He who in the short winter days has looked down from the snowy heights of Sammium and Lucania when the north wind sweeps across the peaks, thrilling through his very frame, and chilling him to the bone, and descended to the green sunlit shores of the Tuscan sea, will understand how the races of the inland Apennines constantly swooped down upon the plains like beasts of prey driven by frost and hunger to attack the farmyards below.

When compared with Greece (the Hellenic peninsula), Italy appears to be highly privileged. The Italian climate has a more maritime, and the Greek a more continental character. The winds, sweeping down from the pole, lend to the Grecian sky a marvellous clearness and purity; but seen by the eye of a climatologist, it loses much of its charm; it is certainly clearer than the Italian, but more inclement, more changeful, and more subject to sudden contrasts. Thus the difference in the average temperature of the warmest and coldest months is in Athens 39·5 degrees, and in Palermo, which nevertheless is situated in the same latitude, only 25 degrees. The rainfall of Athens is only fifteen inches, while that of Rome is thirty-two inches. These figures enable us to understand the poverty of Hellas, and at the same time to admire the unexampled energy of its inhabitants, which alone could have succeeded in raising such a poverty-stricken country to such a high pitch of historical greatness. The flora here, too, is divided into three zones, according to its height. The central-European flora descends from the north, and occupies the greatest part of the country; on the colder heights, which rise like islands from the tangled ridges of the mountain chain, we find an alpine vegetation, such as is only attained in a few points in Italy or Spain. A belt of green plants girdles, with a true Mediterranean flora, the whole peninsula from Trieste to the delta of the Danube, in which desert plants, central-European and evergreen vegetation meet. It is not until we reach southern Albania, the eastern part of Roumelia, and the Morea, that we find the evergreen vegetation more diffusely spread over the country.

The Mediterranean climate is developed to perfection along the coast of France; and nowhere is a more sudden change from one flora to another perceptible than between Montelimart and Orange, in the Rhone valley, where the culture of the olive begins. The impression is so much the stronger because there are no Alps to be crossed, as is the case in our entrance into Italy; but the southern plant forms of the Mediterranean flora are seen in the narrow valley of Donzere in immediate juxtaposition with the vegetation of northern Europe, and in such abundance that six hundred plants are found in France which are restricted to the triangle between Nice, Orange, and Perpignan.

In the Spanish peninsula the evergreens are almost everywhere distributed; and yet none of the peninsulas of Southern Europe is climatically richer in its number of divisions. The parched highlands contrast with the moist Atlantic coast, and the inclement winter of Madrid with the hot plains of Andalusia. The mountains of the northern boundary, the Pyrenees and the Cantabrian mountains belong to the flora of Northern Europe; immediately adjoining the latter mountain chain begins the wide table-land that, with an average level of 1,900 feet, forms a separate botanical region divided by numerous mountain chains. It corresponds with the evergreen region by its rainless summer, and contains many of its plants, being, however, distinguished from it by the greater severity of the winter and the greater dryness of the air; the Spanish highlands are in summer drier than the coasts of the Mediterranean. But even in the lowland valleys of Murcia and Aragon a steppe-like formation has taken possession of the soil in the one place because table-lands or mountains keep back the moisture-laden winds, and in the other because in the only place through which the sea winds could possibly enter, the sirocco blows from the Sahara; and the traveller journeying through these wastes in the dry season readily believes the Spanish proverb, that the lark which would fly across Castile must carry its food with it. From what has been said it follows that there are now few coasts left where the climate thoroughly realizes the conditions of the Mediterranean flora; but even here important climatic peculiarities are imprinted on the three coasts, according to their respective positions. On the eastern coast the rainy season is less strongly marked than in Portugal, and southern Andalusia owes its independent position to its southern latitude and the nearness of the African coast, with which it has exchanged many plants.

Lastly, the mountain regions of the north of Portugal, like the highest peaks of Spain, exhibit a north European flora such as is also seen on the heights of the Apennines, and in a still higher degree upon the Balkan peninsula.

The Mediterranean flora is divided into three principal formations,—forests, shrubs, and open meadows; the latter having in many places (for instance, in the Spanish plateaus) almost the characteristics of the steppe. The region is not exactly rich in woods; but it is by no means so poor in this respect as certain descriptions would lead us to believe. On the borders of the Spanish table-land, especially in the south-east, there are extensive pine woods. The picturesque valleys of Estramadura are rich in evergreen oaks; while on the granite formations of the Sierra Morena, and along the sandy south-west coasts of Andalusia, from Gibraltar to the mouth of the Guadiana, extend the most magnificent forests of cork, oak, and pine. Portugal also can scarcely be called poor in forest land, especially in the mountain districts north of Tajo. In Italy the southern Apennines are richly wooded, in the Grecian peninsula, the north of Albania, Eubœa, and Pindus. It must, however, be said that the evergreen trees form as a rule only open plantations, and are inferior in size to our own forest trees. The evergreen shrub formation encroaches everywhere among the forest growths; and as many of the trees have a tendency to assume a shrub form, it must be assumed that the climate of the Mediterranean region is better fitted for shrub vegetation than for tree growth.

Carob Tree (*Ceratonia Siliqua*).

The evergreens belong to the laurel and olive forms; the former having the broad leaf of the beech, and the latter the narrow willow leaf. But the laurel form finds its truest expression, not in any native tree, but only in the cultivated lemon and orange (*Citreus medica* and *C. aurantium*). The laurel (*Laurus notulis*), appears generally as a shrub six to nine feet high; and seldom attains the height of a tree twenty to twenty-four feet. The same may be said of the evergreen, the common jujube (*Zizyphus vulgaris*); while the common holly (*Ilex aquifolium*) often appears as a stately tree, whose leaves lose both the curved edge and the thorns which they exhibit with us. The evergreen oaks (thirty-six to forty feet high) have not the beautifully marked leaf of our own English oaks; the only forms universally distributed are the evergreen oak (*Quercus ilex*), and the coniferous oak (*Quercus coccifera*). Among those species which are restricted to certain localities are the cork oaks (*Q. suber, Q. occidentalis,* and *Q. pseudo-suber*) found in the west; and the most important of the eastern forms, the Valonia oak (*Quercus ægilops*). Almost the only representative of the olive form is the olive tree (*Olea Europæa*), probably an immigrant from the East, whose fruits contain a valuable oil, and whose significance in the physiognomy of the country has become by its wide cultivation of the greatest importance. A unique and peculiar form is the feathery-leaved carob tree, whose sweet fruit pulp, enclosed in a long pod, creates for the plant a prominent position among food plants.

In the series of the evergreen shrubs a gradual and continuous diminution of the size of the leaf is perceptible, until the leaf finally disappears, or is transformed into thorny organs. The largest leaves are possessed by the oleander form (*Nerium oleander*), and several varieties of helianthemum and cistus, from some of which (*Cistus creticus,* the cistus rose, etc.) exudes the once famous resin laudanum. Next in order of size comes the myrtle leaf, with its widespread *myrtis communis,* the mastic tree (*Pistacia lentiscus*), and the true pistachio (*Pistacia vera*), together with the box tree (*buxus*), Alexandrian laurel (*ruscus*), and several others. The spear-shaped leaf of the heath form is exhibited in many shrubs, especially by the rosemary (*Rosmarinus officinalis*), a few cistus varieties, and seventeen true heaths, among others the tree heath (*Erica arborea*), to whose family belong the strawberry tree (*Arbutus unedo*). Another peculiarity of the region is the numerous members of the leafless spartium form, thirty-eight brooms, a *coronilla,* and the ephedras (*Ephedra distachya*), a plant belonging to the conifers, but resembling shave-grass. The white-blossomed *Retama monosperma* of Andalusia is described as a shrub six feet high, with branches as thick as an arm, growing upward, and bursting into great clusters of rod-shaped, silvery, glossy, leafless twigs, as thick as a quill, hanging down like those of the weeping birch, and in the month of February developing close sprays of fragrant flowers.

The thorny shrubs are very numerous. They belong partly to evergreen and partly to deciduous-leaved species, especially the tragacanth shrubs (*Astragalus*) and also the rose tribe, which contributes a large contingent to this form of growth.

First among the deciduous-leaved trees ranks the beech form; represented in the mountain districts by almost all the varieties of such trees found in Central Europe, they form along the lower slopes, first of all, the belt of chestnut forests (*Castania vesca*). This tree produces the first impression of the richer forms of a southern flora received by the traveller. But long after the beeches and other northern growths have vanished from the circle of his vision, he is accompanied by the varieties of the oak (*Quercus pedunculata*), and farther on *Q. pubescens, Q. toza, Q. infectoria,* and others), not only through the belt of chestnut forests, but even into the evergreen coast region; and the same holds good of the familiar forms of elms and poplars. The pyramid poplar, indeed, was brought from Italy to the north; hence its usual name of Italian poplar (*Populus Italica*), and the white or silver poplar (*Populus canescens*) is said by Mommsen to be the finest tree in Greece. The forms peculiar to the south include the almond tree, pomegranate, and the two mulberry trees (*Amygdalus communis, Punica granatum, Morus alba,* and *Morus nigra*). It is seldom possible to determine with certainty the native place of such valuable trees as these, but the researches instituted to discover it shews us that they were all of them known in the classic ages of Greece, and that even at the present day they are regarded as native growths, both in the East and in North Africa, although the length of the period of vegetation, and the fact of their unequal advance northward, shew that they have not the same original home. The pomegranate tree nowhere crosses the boundaries of the Mediterranean flora, while the region of culture for the almond tree advances along the Rhine to lat. 49°; the black mulberry corresponds to the climate of the vine, and the white seems to have sprung from a steppe climate, although Italian naturalists are of opinion that the western silk trade was carried on for a considerable time by the help of the black mulberry alone, but only reached its present height of development when in the fifteenth century the white mulberry was transplanted from Asia to Europe.

The traveller whose chief object is beauty of scenery is by no means

FIGS AND POMEGRANATE (*Punica granatum and Ficus carica*).

advised to choose the banks of the Po for his wanderings. The scene presented is an unattractive plain. On either side of the road rise in endless monotony long avenues of poplars, whose long straight lines meet the eye wherever it turns, and run together in the distant perspective. Moreover the mulberry tree itself is one of the ugliest of plants. From the stunted trunk, which, like that of the willow, suddenly stops short in its growth, shoot forth the scanty, straggling branches, stretching out their wasted arms as if for help, the mud of the last inundation still hanging from them in the misty air. We refer the reader to our former remarks upon the subject of silkworm rearing.

Much more rarely seen than the trees which we have just named are the ash trees of the south of Europe, the commonest of which is the manna ash (*Fraxinus ornus*), an insignificant tree which is little more than a shrub in Roumelia. Widely cultivated also is the feathery-leaved sumach (*Rhus coriaria*) and the walnut (*Juglans regia*), together with the fever tree (violet tree, *Eucalyptus globulus*), distinguished by its pinnate bluish-green leaves. We have spoken before of the introduction of this tree into the Campagna.

The birch is scarce; alders are more common in Italy, and the silver lime (*Tilia argentea*) in the peninsula of Greece. A still more striking feature in the landscape is the eastern plane tree (*Pl. orientalis*), which is wont to accompany the dwellings of man from Greece and Macedonia to the distant steppes on the Indus. The fig tree (*Ficus carica*) presents another striking plant form, and its culture now extends throughout the whole of the Mediterranean flora. Akin to the willow are the *Elæagnus* or oleaster, and the almond-leaved pear tree (*Pyrus amygdaliformis*). Of the numerous shrubs bearing deciduous leaves we need only mention the richly represented broom tribe (*Adenocarpus sarothamnus*), the mallow-like *Lavatera olbia*, the aromatic tree (*Vilex agnus castus*), forming widespread bushes along the banks of rivers, the euphorbia (*E. dendroides*), *Prunus prostrata*, a pretty little dwarf shrub, recalling the dwarf birch in its growth and foliage, but crowning the bare rocky *débris* of the highest peaks with vivid crimson flowers; and lastly, the caper tree (*Capparis spinosa*), found in great abundance, both wild and also cultivated, and whose unopened buds form the capers of commerce.

Conifers claim an equal share with non-coniferous trees in the composition of the forest. They not only frequently form the upper forest region of the mountains, but are distributed in exclusive species far along the warm coast lands. Two firs inhabit almost the whole area of the evergreen region; the pinea and the aleppo fir (*Pinus pinea, P. halepensis*). The former, a tall and beautiful tree, whose upward-pointing branches are thickly clothed with evergreen leaves, belongs to the most characteristic forms of the flora, and is passed over by no painter of southern landscapes. Of the two coast pines, the Bordeaux fir (*Pinus pinaster*) does not extend farther eastward than Dalmatia, where it is forced to evacuate the field to make room for the genuine *pinus maritima*. The yew tree (*Taxus baccata*) is widely distributed, while the red pine of the north (*Picea vulgaris*) is utterly unknown beyond the Alps, and is replaced by the silver-leaved fir tree (*Albies pectinata*). Worthy of mention also is the *Abies pinsapo* and the juniper species (*Juniperus sabina, J. oxycedrus, J. lusitanica*, etc.), together with the cypresses, the best known of which is the slender Italian cypress (*Cupressus sempervirens*). The only palm found is the dwarf-palm (*Chamærops humilis*), in a really wild state. It is nowhere found in greater abundance than along the banks of the Guadalquiver, where it covers the whole plain of Seville, as far as Cordova, with millions of individual specimens. Along the coast of Spain it is common everywhere, while it is only found in solitary instances in Rome and Nice; it is scarce in South Italy and in the islands of the Grecian archipelago, and still scarcer in Greece itself. The fruit of the date-palm, which is cultivated in several places, ripens only under the careful culture of the inhabitants of Elche, in the south of Spain; on the northern boundary it will not even blossom.

The native succulent plants are insignificant. Ice-plants (*Mesembryanthemum*), stapelias (*Stapelia Europæa*), and kleinias recall the forms of South Africa; but so much the greater is the part played by the opuntias (*Fici indichi*), the fig cactus (*Opuntia ficus indicus, O. vulgaris*, and *O. amyclæa*), and agaves (*Agave Americana*), as well as by the common aloe (*Aloë vulgaris*), an African immigrant plant, perhaps only degenerated into its wild state.

The strange and striking form of the Rafflesia is represented by the *Cynomorium coccineum* and the cistus (*Cytinus hypocistus*), two parasitic plants, of which the former frequents the roots of the myrtle, and the latter those of several species of cistus.

Climbing plants often overrun the open undergrowth of the woods, or climb, sometimes with pliant, sometimes with wooded stem, to the crests of the trees. Widely distributed also is the extremely thorny sarsaparilla plant, or smilax (*Smilax aspera*), and the yam (*Tamus communis*), which penetrates as far as Switzerland; the noblest species is the vine (*Vitis vinifera*), which, growing wild in Bulgaria and Roumania, climbs up the trunks of the trees, and is also cultivated to a very great extent, not only for its fiery wine, but for its raisins and currants.

The cane and reed grass recalls the bamboo of the tropical zone; the Spanish cane (*Arundo donax*) grows already in Lombardy to the height of twelve to fifteen feet; and the Chinese fodder grass (*Sorghum saccharatum*), largely cultivated in the valley of the Po, reaches the same height. A corresponding degree of succulence is exhibited by the Spanish esparto grasss, of which a passing mention was made in our description of the Alfa Sea. The papyrus is only found in one rivulet of Sicily, near Syracuse. Annuals are numerous, but turf-forming meadow grass is scarce; the rich juicy meadow land being accordingly replaced by the most varied herbaceous and bulbous plants. Scarcely is the short winter at an end when the plain is covered with myriad blossoms; it is the time for narcissus, tulip, hyacinth, crocus, and orchids. Then come the yearly leguminous plants, luxuriant composite and umbelliferous growths, and lastly the aromatic labiatæ.

COMMON LIQUORICE, OR SPANISH JUICE (*Glycyrrhiza glabra*).

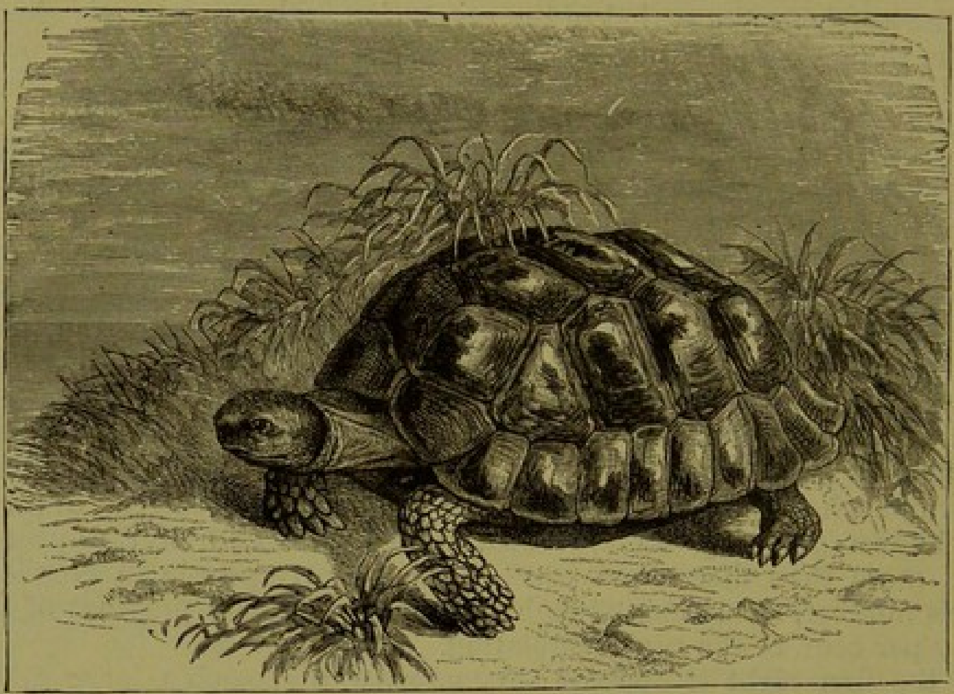
Who is there who does not gladly linger over the words of poetic association, when mention is made of the asphodel meads of Attica (*Asphodelus ramosus*), or the noble outlines of the acanthus leaf (*Acanthus mallis*)? It is not by any means the slightest of the many advantages which fell to the lot of classical antiquity, that the beauty-loving mind of the Greek was inspired, not only by the richer and more brilliant colouring of the landscape round him, but also by the exquisite forms of the organic life which furnished him with studies for his works of art.

The number of flowerless plants is of course also great; especially widely distributed is the eagle fern (*Pteris aquilina*), which covers wide stretches of what was once wooded country, and in many places forms the only undergrowth, and stifles every other plant.

Very considerable also is the number of cultivated plants. Many trees and shrubs have been already mentioned. Among the products of the soil which are seldom or never seen among ourselves are maize and rice, both of which penetrate as far as Lombardy, and are the most important cereals. Besides these we must mention cotton, which thrives admirably to the south of Valencia and Naples, and also in the Crimea; tobacco, liquorice (*Glycyrrhiza echinata* and *glabra*), madder (*Rubia tinctorum*), safflower (*Carthamus tinctorius*), saffron (*Crocus sativus*), aniseed (*Pimpinella anisum*), sesam and almond, *Arachi hypogæa*. We have already called attention to the high estimation in which the tomato is held, sugar-cane is grown in a few places in the south of Spain and in Sicily. Our northern fruit trees are widely distributed, although some of them, especially the apple and pear tree, are not found in many places until the chestnut region is reached; at any rate, it is there that they produce their best fruit.

Noteworthy also are the influences of climate upon the productions of the soil. The farther southward we advance from the Alps, the earlier we find the time of harvest, and as the seed in these districts is also earlier sown than in the northern, the period of the vegetation is thereby greatly shortened. While the winter corn, for instance, requires in Berlin 299 days, the period in Rome, Naples, Palermo, and Malta is respectively 242, 195, 171, and 164 days; so that in the south, several crops can be obtained in one year from one and the same field. Even in Carinthia, in the southern Alpine valleys not belonging to the Mediterranean region, the wheat harvest is followed in autumn by a crop of buckwheat. In Lombardy the life-giving light power of the sun is intensified to such a degree, that splendid harvests can be raised between the fruit trees and the vines which connect them together. Farther southward, where the summer rains are wanting, the dry season restricts the period of vegetation within narrower limits; but this limitation is counteracted by the energy of man, who turns to account the running waters of the mountain districts for agricultural purposes. Unfortunately the grain, especially in Upper Italy, is not allowed sufficient time to ripen, and the use of the unripe maize, or of such as has been rotted by damp, causes the outbreak of a terrible disease known as the *pellagra*, which, toward the end of the year 1879, attacked more than fifteen per cent. of the country people in North Italy; while this number, disastrous enough in itself, rose in the province of Brescia to eighty per cent. of the rural population.

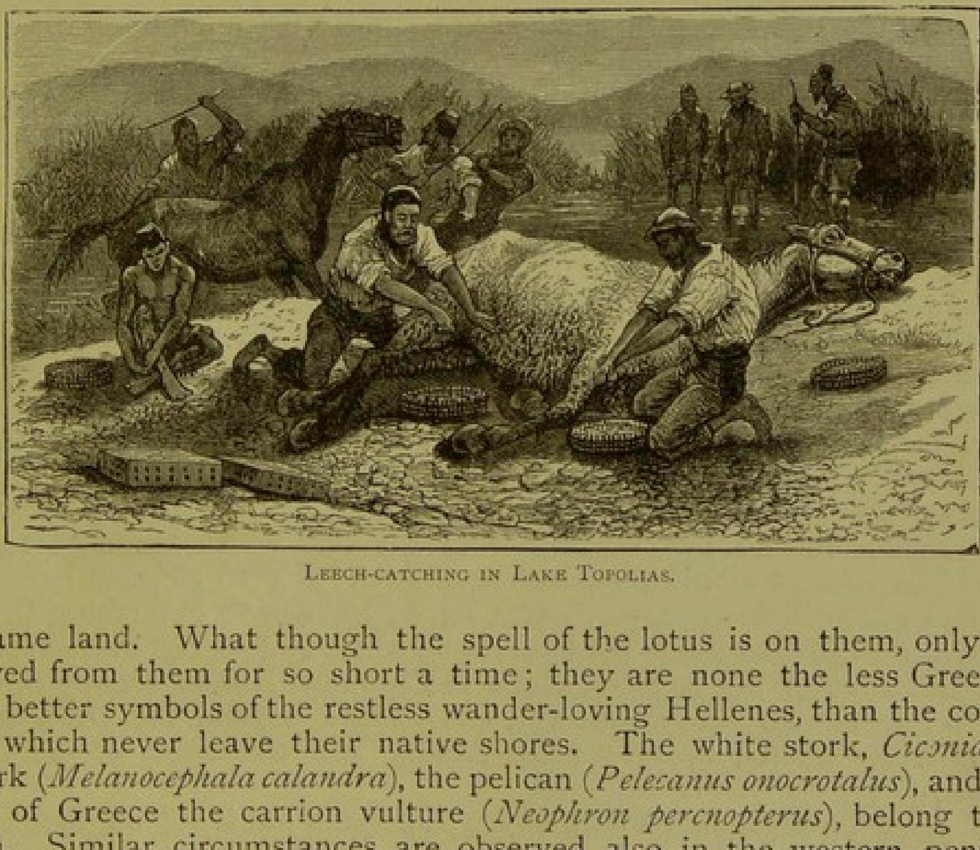
At the first sight it appears very unusual that such a large and wide piece of water as the Mediterranean should not separate faunas of different character, particularly as its average depth is more than 9,000 feet; but a closer investigation shewed that it only needs an elevation of barely 1,500 feet to effect a wide connection by land between Tunis, Malta, and Sicily, and also to unite Spain with Morocco. Indeed, it is very probable that at a comparatively recent date the Mediterranean was divided into two basins, an eastern and a western; for in Malta, numberless remains of three species of elephants have been discovered, animals which could not by any possibility have lived upon a small rocky island. The former connection between South Europe and North Africa is moreover indicated in Gibraltar by the discovery of fossil remains of the hippopotamus, and in Greece by many fossils of African forms; besides which the lion has been seen in Macedonia, even in historic times. No less close is the connection between the fauna of the Mediterranean region with that of Central and North Europe, notwithstanding which the region possesses many exclusive and characteristic forms; the genet (*Viverra genetta*) is found in Spain and in the south of France. Lower Italy, Sicily, and Greece possess the porcupine (*Hystrix* *cristata*); the rocky mountains of the islands of Sardinia and Corsica are the home of the only wild sheep in Europe, the moufflon (*Ovis musimon*); Dalmatia and Greece afford shelter to the jackal (*Canis aureus*), and the lynx (*Lynx pardinus*) is found in all the three peninsulas. Whether the common Barbary ape (*Macacus innus*) was originally a native of Europe, or brought over from Africa, is still as much a disputed question as whether the fallow deer (*Dama vulgaris*) found its way into Central Europe from the Mediterranean region. Among the larger mammals common to other parts of Europe, we may mention as belonging to all the three peninsulas the bear (*Ursus arctus*), not uncommon in the south, wolf (*Canis lupus*), fox (*Canis vulpes*), and chamois (*Capella rupicapra*), together with the wild cat (*Felis catus*), especially common in the east. The two western peninsulas possess a characteristic domestic animal in the buffalo (*Bos bubalus*), brought into Italy only toward the end of the sixth century.



GREEK TURTLE (*Testudo Græca*). Length, 12 inches.

Still less exclusive than the mammals are the birds, but the number of individual forms is most extraordinary, because numerous northern species pass the winter in the south of Europe, and many African ones spend the summer there.

A few of the constant birds of Greece receive in the winter an addition to their numbers by the immigration of birds of their own species, such as the plover, jackdaw, and black water-fowl; but the majority of the species which arrive in winter find no other representatives in Greece; for instance, many ducks and aquatic birds, snipe, curlew, sandpiper (*Iotanus*), etc., which are found in great numbers during the winter months. The country which thus provides a winter home for so many of our birds, larks, thrushes, blackbirds, wagtails, starlings, snipe, etc., is after all no land of promise for the stranger guests. On sunny days, it is true, the familiar sounds may be recognised; flies buzz against the window panes, bees fly busily to and fro; among the flowering shrubs, lizards dart hither and thither in the sunshine, and it is possible to fancy oneself transported to a northern spring; the birds, too, seem to be filled with the same delusion; they sing and call, until perhaps with the very next day fine weather disappears, and their dream vanishes with it. The greater part of the time the weather is bad, every song has to be hushed in presence of the anxious search after food, no nest is built, no love song warbled, many species moult, and the common trouble keeps all in flocks together. Lean and hungry, but bravely and joyously, they set out in spring, on their return to the north, the old familiar breeding places of their home. After their departure new troops alight upon the southern shores, most of them only to pass over, and only a few to remain in the country. Among the latter are swallows, quails, cuckoos, storks, cranes, bitterns, herons, singing swans, and other species. Latest of all arrive the summer birds, the "African strangers." Most of these come late, and leave early, many of them not staying for five months, as if they were home-sick for Africa and the tropics, and were only passing guests in Greece. But Africans they are not. Their cradle stood in Greece, and new homes await their nestlings every year in



LEECH-CATCHING IN LAKE TOPOLIAS.

the same land. What though the spell of the lotus is on them, only to be removed from them for so short a time; they are none the less Greek, and much better symbols of the restless wander-loving Hellenes, than the constant birds which never leave their native shores. The white stork, *Ciconia alba*, the lark (*Melanocephala calandra*), the pelican (*Pelecanus onocrotalus*), and in the north of Greece the carrion vulture (*Neophron percnopterus*), belong to this region. Similar circumstances are observed also in the western peninsula, but varied, as might be expected, by many local differences; thus the flamingo (*Phœnicopterus roseus*), is a migrant bird of Spain and Sicily; the bustard (*Otis tarda*), an inhabitant of the Spanish highlands; the vulture (*Gypætus barbatus*) builds its eyrie in the mountains of Spain, Corsica, and the peninsula of Greece.

Among lower animals found in the Greek and Italian peninsulas, with the adjoining islands, we may mention the Greek turtle (*Testudo Græca*), the chamæleon (*Chamæleon vulgaris*), the scorpion (*Scorpio Europæus*), distributed over the whole of Southern Europe, as far as the Tyrolese Alps and Carpathia; the tarantula (*Tarantula apuliæ*), famed in legend, found in Spain and Italy; a fawn-coloured spider, one inch and a half long; the *Latrodectus*, another greatly dreaded spider; the locust (*Cicada plebeja, orni*, etc.), whose chirp is characteristic of the southern summer; and lastly, the leech (*Hirndo officinalis*), with which the south of Europe, and especially the south-eastern districts, supply nearly all the demand of the markets.

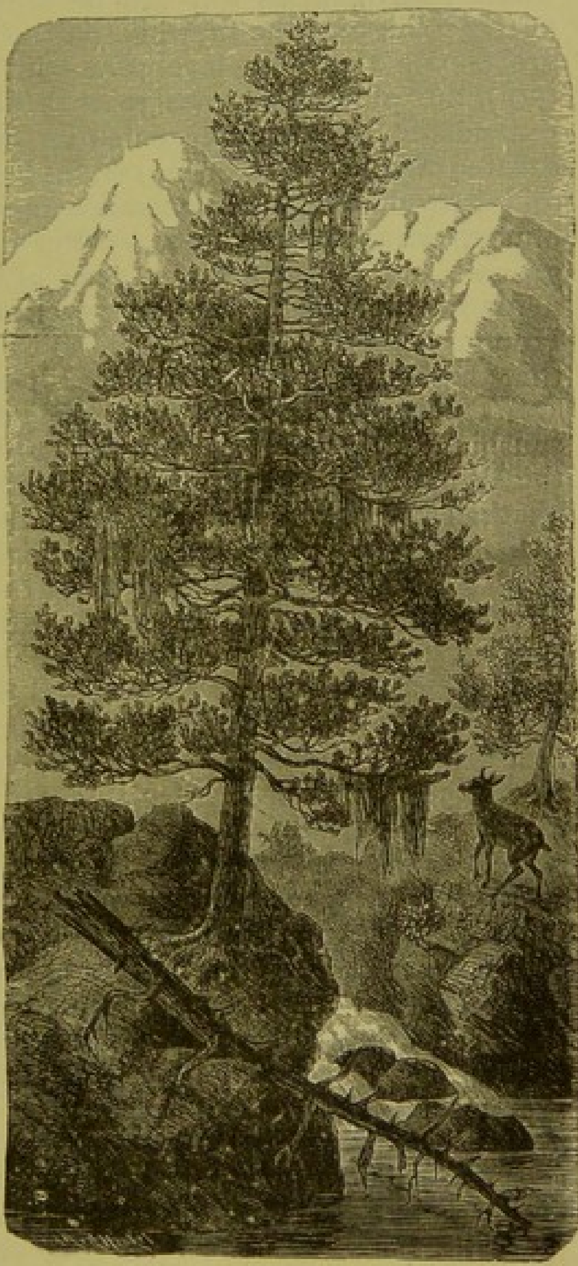
The European Forest Region.

The north-eastern countries of Europe which are still left for our consideration, the region round the mouth of the Petschora, belong to the arctic flora, and the south-eastern to the steppe region. If we do not treat of these separately, it is because both the flora and fauna of the comparatively small territories can scarcely be distinguished from those of the Asiatic districts of the arctic regions which have been already described; and even the forest region may be dismissed in fewer words, so as not to be compelled to clothe in new phrases facts already generally known.

In our description of the artic flora of North America, we called the attention of our readers to the influence of the Gulf Stream upon the climate of Europe; but the genial influence of the Atlantic Ocean, as Dove has shewn, is felt throughout the whole of Europe, as far as the Ural Mountains; the flora of the Asiatic forest region being accordingly much less luxuriant than that of the European. The most perfect expression of the sea climate is found in the beech (*Fagus sylvatica*), which excels in this respect all other forest trees by which the physiognomy of the landscape is determined. During its period of vegetation, which lasts for five months, it needs, together with a sufficient quantity of moisture, a temperature never falling below 50°, and therefore its northern boundary, running from the north-west to the south-east, begins in the southern boundaries of Norway (lat. 59°), and traverses Europe almost in a straight line across Calmar (lat. 57° on the east coast of Sweden) and Königsberg, as far as Padolia, to continue its advance beyond the steppes, through the districts belonging to the Mediterranean region in the Crimea and the Caucasus. Farther northward penetrates the oak (*Quercus pedunculata*), whose limits deviate but slightly from the line which connects together places of an average yearly temperature of from 36·3° to 38°, and passes near Christiansund (on the coast of Norway, lat. 63°), across to Petersburg (lat. 60°) and Perm (lat. 58°), as far as the Ural chain, which it does not overstep. Then comes the zone of the conifers, which in European Russia occupy the wide space to the boundary of tree growth, and extend beyond the Ural, through the whole of Siberia, as far as the Amoor and the coast of the Sea of Okhotsk.

Of these three climatic zones of the European forest region, the zones of the beech, oak, and pine, the first is again subdivided into three sections, which may be designated by the chief characteristic tree of each one as the zones of the evergreen shrubs, the silver fir (*Abies pectinata*), and the bitter oak (*Quercus cerris*). The zone of the evergreen shrubs comprises the northern boundary of Spain, the greatest part of France, Great Britain, the Netherlands, the coast districts of Germany, as far as the Oder, Denmark, and the south of Scandinavia, as far as the beech can thrive. The zone of the silver fir includes Dauphiné in France, Switzerland, the greater part of Germany, Poland, Gallicia, and the Austrian half of the Austro-Hungarian kingdom. The zone of the bitter oak, lastly, is composed of the Hungarian half of the last-mentioned kingdom, together with the countries extending to the Balkan chain and the steppes near the Black Sea. These three zones moreover correspond in some measure to definite degrees of the sea climate, if the latter be expressed by the difference of temperature between the hottest and coldest months; the first answering to 54·5° to 63·5°, the second to 63·5° to 73°, and the third, to 70·8° to 75°.

The plants which serve as characteristic of the three zones of the beech climate are but imperfectly fitted for exemplifications of our statement, as they do not altogether correspond to the limits of the natural sections of the flora. In the first place, the evergreen shrubs, *Abies pectinata* and cerris oak, occupy a larger space in the southern parts of Europe, which belong to the Mediterranean region, than they do in France or Great Britain, Germany or Hungary; and in the zone of the birch climate the oak, birch, and larch of the two other zones are also native; nevertheless, the zones in question represent in their vegetation, considered as a whole, distinct and characteristic plant regions.


SIBERIAN STONE PINE *(Pinus cembra)*.

The forests of our region are surpassed by those of many other floras in the number of varieties, both of their coniferous and non-coniferous trees; and yet nature, making use of the simplest materials, has lavished a wealth of beauty upon our countries. Our forest trees are among the most beautiful in the world; each has its own marked impress, and art draws inexhaustibly from these unceasing springs, where the formation and grouping of individual forms more than compensate for the comparative want of diversity of organisation.

The region possesses nine species of coniferæ, which, arranged according to the extent of their distribution, are classed in the following order: Scotch fir (*Pinus silvestris*), red pine (*Picea vulgaris*), larch (*Larix Europæa*), Siberian stone pine (*Pinus cembra*), yew (*Taxus baccata*), white spruce (*Abies pectinata*); *Pinus pinaster*, or Bordeaux pine, extending from the south of Europe along the coasts of France; the larch fir (*Pinus laricio var austriœa*), from the south of Europe to the Viennese forests; the dwarf pine (*Pinus pumilis*) in the Alps, Carpathians, and Sudetian Mountains. This tree is exclusive in these countries, seldom, however, growing to the height of a tree, and only in the western Alpine valleys.

Pine and larch form the most extensive forests. In western Europe the pine is the conifer of the plains, and the fir the prevalent mountain tree; and even slight differences of level sometimes call forth this distinction, as is the case on the Luneberg heath. In the north of Russia, where the forest is only interrupted by swamps, the reverse is the case; and the clayey lowlands of the red sandstone soil are covered with fir forests, while the sandy hill country of the diluvial districts is overgrown with pine, which does not, however, avoid water when porous soil can be found. In the Alps the pine is not found nearly so high as the fir, while on the plains of the south of Norway both trees grow upon the same level; and in Lapland, where, along its northern limit (70°), the pine sometimes reaches the height of more than sixty feet, and extends to the extreme outskirts of the forests, the fir is left behind at a greater distance (67°, or, in certain localities, 69°). All these great and manifold irregularities of appearance may be explained in the case of the pine, almost without exception, by the long root, which penetrates deep into the ground, and by the greater need of light of the wide-spreading leaves; but neither of these circumstances explains its absence from the valleys of Hungary, where the soil is suited to it in every respect. Griesbach suggests that the tree was not able to cross the heights which surround the valley.

The larch is a tree that seeks the light, as is indicated by the softened sunshine of its forests. Its Siberian varieties inhabit the north-east, between the White Sea and the Ural, are absent from the whole plain of Russia, from Viatka (59½°) to the Carpathians, and then reappear in their European form in Switzerland, where they meet the highest forest region of Switzerland. The same districts are also the home of the *Pinus cembra*.

The number of conifers, according to Griesbach, is much smaller than that of non-coniferous trees. The whole region of the beech includes seven varieties. Besides the beech, we find the hornbeam (*Carpinus betulus*), *Quercus robur*, elder tree (*Sambucus nigra*), lime (*Tilia grandiflora*), and two mountain ashes, the *Sorbus aria* and *Sorbus torminalis*. Of these species, the elder tree exceeds on the Norwegian coast the limits of the oak, and reaches as far as lat. 64°.

Thirteen non-coniferous trees, chiefly more southern forms, descendants of those of the mountain districts belonging to the Mediterranean region, inhabit certain parts of the beech climate. In the southern half of the zone of evergreen shrubs, about as far as the Moselle, the chestnut (*Castanea vesca*) is so characteristic a tree, that the whole zone has been named from its presence the zone of the chestnut. Beside this tree is found the French maple (*Acer monspessulanum*). To the oak zone belong the snowball-tree (*Acer opulifolium*), the bladder-nut (*Staphylea pinnata*), and two rarer mountain ashes, *Sorbus domestica* and the bastard mountain ash (*Sorbus hybrida*). The hairy oak (*Quercus pubescens*) is common to both the western zones of the beech climate. Of the remaining trees, five are found also in the third zone, and advance there to different points upon the lower Danube, the bitter oak extending farthest, then the silver lime (*Tilia argentea*), syringa or Spanish elder (*Syringa vulgaris*), red linden (*Tilia rubra*), and the hazel-nut tree (*Corylus colurna*). The wild cherry (*Prunus cerasus*) is found as a native growth only in Bosnia and Illyria.

The region of the beech climate and the oak zone possess fifteen species in common; first of all, the German birch (*Betula verrucosa*), the common oak (*Quercus pedunculata*), and the small-leaved lime tree (*Tilia parvifolia*). The three varieties of maple (*Acer campestre*, *Platanoides*, and *pseudo-platanus*) which are indigenous to a great part of Central Europe, do not extend to the arctic limit of the oak, but are left behind at various distances. The ash (*Fraxinus excelsior*) is seldom found in large numbers together; and the three European elms (*Ulmus campestra, Ulmus montana,* and *Ulmus effusa*) are still more scattered in their growth, appearing generally only as isolated trees among the other species of which the forest is composed. The black alder (*Alnus glutinosa*) is restricted to the neighbourhood of running water, and forms by this circumstance a transition to the willow. Lastly, this group contains the following wild fruit trees: the cherry (*Prunus avium*), apple and pear tree (*Pirus malus* and *communis*), neither of which penetrates as far to the north-east as the oak; and although the apple tree, the hardiest of the three, advances in Norway to the limit of the arctic region, it cannot in Russia bear even the climate of St. Petersburg. The Swedish hawthorn (*Sorbus intermedia*) possesses only a limited area in the southern parts of Sweden, but has extended from its home to the German and Finland coasts of the Baltic.

The Russian oak zone has no exclusive tree forms, but it possesses, in addition to the ordinary coniferous trees of Central Europe, the heart-shaped leaved, or Russian maple (*Acer tataricum*).

Only seven non-coniferous trees are found within this region: the bird-cherry tree (*Prunus padus*), the common mountain ash (*Sorbus aucupyria*), the trembling, white, and black poplar (*Populus tremula, nigra* and *alba*), the northern birch (*Betula alba*), and the white alder (*Alnus incana*). Of these, the birch either ascends gradually to the mountain regions on this side of the Baltic, or is found on the colder soil of the marshes in a hairy variety; the marsh birch (*Betula pubescens*), and also the white alder, do not advance far into the region of the beech climate. It should be noticed that only three trees are common to all the zones of the Europo-Siberian forest region, namely, the bird-cherry, the mountain ash, and the pine.

When the periodic foliage of the beech and other non-coniferous trees passes to stemless shrubs, we reach the *Rhamnus* form, which is distinguished from the physiognomy of the willow by a broad and variously shaped leaf. Such shrubs generally form the undergrowth of the forests, and seldom appear as an independent form, like the alder-bushes and dwarf birches of North Germany and Russia. The component parts of the undergrowth are more diversified than the trees by which they are overshadowed, but the denser and more closely grown plantations of the conifers allow fewer wooded growths to appear than are found among lighter and more open forests. Sometimes, indeed, they exclude every foreign intruder, with the exception of the autumn fungi. The representatives of the rhamnus form are found everywhere, and form about twenty varieties, belonging to some twelve families; as a more detailed enumeration would occupy too much space, a few instances of climatic influence upon them and their distribution must suffice. Here, as in the arctic flora, the woody branches become shorter with the decreasing heat, and the leaves grow smaller; as is shewn by the shrub growths of the colder marsh lands and of the higher mountain slopes, for instance, the dwarf birch (*Betula nana*), the shrub birch (*B. fruticosa*), and the gale or bog myrtle (*Myrica gale*). In the warmer climates the rhamnus form passes more frequently into thorny growths than it does in the north; witness the well-known barberry plant (*Berberis*), the hawthorn (*Cratægus oxyacantha*), the sloe (*Prunus spinosa*), together with roses and blackberries. Still more remarkable, perhaps, is the increase of the berry-bearing shrubs in the northern zone of the conifers, not so much for their diversity of species as for the spreading habit of the individuals; so that it seems as if the longer the winter lasts, the greater abundance of such food to sustain animal life must be stored and preserved fresh and palatable under the covering of snow. Our remarks in an earlier chapter, upon the berrry-bearing shrubs of the American Tundra, are true also in like manner of our bilberry (*Vaccinium myrtillus*), whortleberry (*V. uliginosum*), cranberry (*V. vitis Idæa*), and crowberry (*Empetrum nigrum.* The distribution of climbing plants has also a climatic significance. In our forests they are not particularly numerous; in the northern and eastern regions they decidedly decrease: the hop (*Humulus lupulus*) being restricted to the non-coniferous woods, and the ivy (*Hedera helix*) to the beech climate; clematis, honeysuckle (*Lonicera*), blackberries, and roses, are other familiar representatives of the lianas in our regions.

The willow form is represented by numerous willows (*Salices*), to which must be added, on the banks of a few southern rivers, and on the coasts of the North and Baltic Seas, the sea-buckthorn (*Hippophaë rhamnoides*). In the south-west of the region, as far as the Danube and the northern base of the Carpathians, the willows by the running waters are accompanied by the tamarisk (*Myricaria germanica*), a plant recalling African forms. Lastly, beyond the tree limit appear shrub forms, which either repeat the types of the Arctic flora, or are common to it, and to the alpine flora, as the rhododendron.

Among the characteristic forms often appearing together as thoroughly independent formations are the smaller conifers, the before-mentioned dwarf pine (*Pinus pumilis*), and the different forms of the juniper (*Juniperus communis, J. nana*, etc.).

The evergreen heath is a peculiar formation of Western Europe. The common heather (*Calluna vulgaris*) is also found, it is true, in Russia, but in that country it needs, in most places, the shelter of shady trees which keep the ground moist. The wild rosemary (*Andromeda polifolia*) belongs to the marshes, and only isolated instances of wild rosemary (*Ledum palustre*) and wild lavender (*Andromeda calyculata*) are found in the east. A very peculiar position among these shrubs occupy the heaths (*Erica tetralix*), in the north-west of Germany, where they cover not only the arid sand, but the well-watered turf land of the moors; and notwithstanding the great contrasts in the irrigation, they impart to the region a uniform physiognomy. We have yet to mention that all these shrubs grow to a larger size in the longer period of vegetation of the south. On the Luneberg heath, shrubs of twenty to forty inches high are rarely seen, while in Gascony the usual height of such heath shrubs is three feet, and sometimes they attain twice that size.

We may mention here, also, the evergreen shrubs of the western zone, which are dispersed from the Mediterranean region along the coast of the Atlantic. Half of them are heath shrubs, to which two thorny bushes, furze (*Ulex*), and six shrubs of the laurel, oleander, and myrtle forms must be added. Although there are a few among the latter capable of growing into trees like the evergreen oak (*Quercus ilex*), the prickly palm (*Ilex aquifolium*), and the laurel (*Laurus nobilis*), yet this is seldom the case; and the remainder, the box (*Buxum sempervirens*), the singular butcher's broom (*Ruscus aculeatus*), which bears its blossoms in the middle of a leaf-like stem, and lastly the *Osiris alba* seldom grow into plants of any considerable size. The last mentioned plant only reaches to Charente (46°), while all the others are found as far as England, and most of them in Scotland, and some even reach as far as

Norway. But in the Isle of Wight the cherry-laurel tree (*Prunus laurocerasus*) is seen growing freely, though under culture, in every garden, with the olive and the strawberry tree; besides which we must add, as a characteristic mark of the climate, that the myrtle and fig tree live there through the winter in the open air, and even the dwarf palm requires only a slight covering.

Among grasses, the turf-forming varieties are the most important; upon their growth, their closely compressed and coherent root formation, depends the character of the meadows, which are not so developed in any other adjoining region. Their distribution is attached to the presence of running water; but acid grasses are found in stagnant or more sluggish waters, as *Cyperus*, sedges and reeds (*Carex*), cotton grass (*Eriophorum*), rushes (*Scirpus*), and many others. On the lower course of great rivers and their deltas, reed thickets, more especially composed of *Arundo phragmites*, are most widely found; particularly on the lower Danube, where they are seen on a large scale, covering many square miles. In these inaccessible solitudes of the delta, which, however, are inhabited by countless water-fowl, the slender arms of the great river are hidden away as if the dense vegetation prevented them from reaching the neighbouring sea.

The shrubs are variously developed, but in most cases they belong to the subordinate parts of the formations. They adorn lavishly the open spaces of the non-coniferous forests and the open districts of its surroundings; bedded in the turf of the meadow, they luxuriate in a succession of differently tinted blossoms, varying according to the months, and make use of those substances of the soil which the grasses do not need. It should be mentioned that in continental climates, and in the higher forest region of the mountains, their stems are lengthened. Familiar to most of us are the masses of aconite or monkshood, and other tall sub-alpine shrubs which accompany the lower rhododendrons in the neighbourhood of the limit of tree growth.

Ferns have here considerably less importance in the physiognomy of the landscape.

The farther we advance from the Atlantic in an easterly direction, or from Central Europe towards higher latitudes, the more close is the woody covering of the land. While in France the amount of forest land is estimated at 8 per cent., and in the Netherlands it occupies only 6 per cent. of the whole surface, it amounts in Germany to 26½ per cent., and in the Russian governments of Archangel, Wologda, and Olonez it is said to be more than 50, and in Sweden and Norway more than 64 per cent. Although these inequalities are chiefly the natural consequence of the advance of agriculture, yet there are even now still greater sections of the country where the woods retreat from untilled land, such as the heaths of western Europe, the plains of Hungary, and the swamps of Russia, which are in great measure overgrown with shrubs. It is not to be assumed that the heaths of the Baltic plain possessed at all times as little forest land as they do now, for the fossil remains of conifers, found embedded in the turf moors of Hanover, indicate the former presence of forests; while in Russia the present absence of wood may have been occasioned by the stagnation of the water which produced the turf moors in which the trees perished; but it is extremely improbable that the Hungarian plains were ever wooded.

Before the very gates of Pesth, where the sandy plains soon begin on the eastern side, is seen a composite vegetation of isolated growths, partly annuals, partly turf-forming grasses, between which the bare sandy soil is everywhere visible; farther on, in the valley of the Theuz, where the soil is rich in natron, the grassy plain is replaced by the saltwort formation, and recalls the Russian salt steppes. Three formations of grass have been distinguished on the soil which contains no salt, beard-grass (*Andropogon gryllus*), *Stipa*, and the annual grasses (chiefly *Bromus*). Among these varieties are seen flowering shrubs of many different kinds.

As the birch is said to spread abroad more and more in the north, so it has been shewn by statistics that in the north of Germany the conifers have gradually thrust back the non-coniferous trees, and experience shews that they are still the victors in this struggle, as for instance on the western Harz, where the pine has everywhere followed the beech. The reason of this must be sought for partly on economical grounds, but partly also in a certain exhaustion of the soil; for that which is apparent to the farmer within the space of a few years in the rotation of annual cereal crops is accomplished among trees with the same inexorable certainty, but in periods numbered by centuries.

Of food plants, barley advances farthest northwards, reaching on the western coast of Lapland almost to the limit of tree growth (lat. 70°), where it is accompanied by the potato. With a few local irregularities, occasioned partly by the White Sea, its polar limit extends from the northern frontier of the Gulf of Bothnia to the Ural Mountains near the Arctic Circle (65° to 67°). Everywhere, perhaps, it reaches the northern limit allowed by the climate—even the climatic varieties, that is, the varieties modified by the climate, and whose period of vegetation, between the sowing of the seed and the ripening of the crop varies, even in the short distance from Hardanger to Bergen, between 71 and 140 days. The polar limit of wheat corresponds almost everywhere with that of the common oak (*Quercus pedunculata*). Between lat. 60° and 50°, winter rye and winter corn are the chief cereals, being specially predominant in a zone extending from England and Denmark through the north of Germany, Poland, and Russia, to the Ukraine. As to which of the two kinds is the principal product of the country, it depends not on climatic influences, but on the greater or less fertility of the soil, which is again dependent on the geognostic formation, in whose mineral composition a predominance of lime favours corn. It is owing to this fact that England, Mecklenburg, and Poland are privileged; but even on the sandy soil of the Baltic plain the more valuable wheat is often driven away by rye, especially where the marl strata are more generally used; and even below the fiftieth parallel the influence of lime upon the predominance of wheat cannot be mistaken. Lastly, in the southern parts of the region, from France through Germany and Hungary, to the Russian steppes, maize grows.

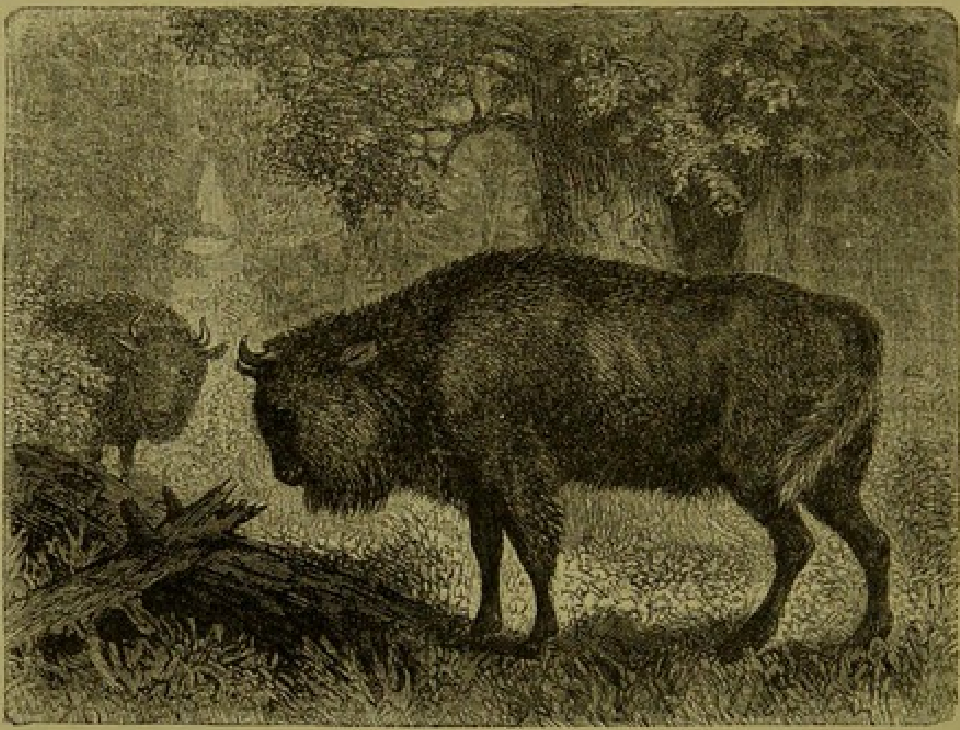
The limit of apple, pear, and cherry trees coincides almost entirely in Scandinavia with that of the oak; then extends from Narva to the Gulf of Finland (lat. 59°), to Moscow (lat. 56°), and thence in a true easterly direction to Kasan, from which place it descends to the steppe; but it is uncertain yet, whether the culture of these trees has in every place advanced as far northward as the climate would permit.

The northern limit of the vine (*Vitis vinifera*) extends from Brittany (47° 30′) almost in a straight line across Luttich to the Rhine (50° 45′), passes through Lower Hesse (51° 20′) and Thuringia, as far as Silesia (Grunberg 51° 55′), and then descends rapidly towards the south, and in Bessarabia to 46°. That in former centuries the culture of the vine extended farther northward, to the south of England, Prussia, and the Russian provinces of the Baltic, is probably due to the fact that in the middle ages, when the means of intercommunication were ill developed, people were content with a wine which in the present day would be despised. In the south the vine is usually reared on trees, which corresponds entirely to its original nature, as it climbs and clings in the countries of the Lower Danube, in Banat and Pontus, twining round forest trees like our hops and ivy. On the climatic boundary of its culture the generous plant has to be exposed to the sun to allow the necessary warmth (especially that of the autumn sunshine, which principally contributes to the formation of sugar in the berries) to reach the fruit. The soil certainly exerts an influence upon the grapes, but the numberless chemical changes which culture has gradually called forth and developed, and on which the soundness, strength, aroma, and flavour of the different kinds of vine depend, are after all climatic varieties due to the varying degree of heat. The number of the varieties is countless. "As many vineyards as many kinds of wine," said Pliny, who divided the delicious juice into one hundred kinds.

The agency of man has greatly modified, not only the original flora, but also the fauna, of the European sub-region, and particularly in its most imposing members, the larger mammals, by restricting them to very narrow limits of habitation. The region is rich in animal life, but its number of exclusive forms is not great; of the mammal class it has only two, the chamois (*Rupicapra*), and the desman or musk rat (*Mygale*); almost exclusive is the blind mole (*Spalax*), which is only found in eastern Europe and the west of Siberia, together with the saiga or steppe antelope (*Colus tataricus*), which inhabits the same districts.

The Alps may be regarded as the true home of the chamois. Their circle of distribution certainly extends considerably farther, since chamois are also found in the Abruzzi, the Pyrenees, the mountains of the coasts of Cantabria, Dalmatia, and Greece, on the Carpathians, especially the peaks of the lofty Tatra, the Transylvanian Alps, and, lastly, in the Caucasus in Tauris and Georgia. Two kinds of desmans are known; one, the musk-rat of the Spaniards (*Myogale pyrenica*), inhabits the Pyrenees, while the second, the desman (*Myogale moschata*), is principally found in the river basins of the Don and the Volga, but also in Bucharest. The same countries contain the best known variety of the blind rat (*Spalax typhlus*).

Worthy of note are the numerous species of bat which are altogether wanting in the arctic region; and the ten different kinds of insectivora. Of the latter the hedgehog (*Erinaceous Europæus*) is the most characteristic; more so than the mole (*Talpa Europæa*), and the shrewmouse (*Sorex*). Carnivora are richly represented. The brown bear (*Ursus arctus*), which replaces the white polar bear, once ranged through the whole of Europe, but is now almost extirpated in France and the Austro-German countries, and is no longer known in Great Britain, Belgium, Holland, Germany, and Denmark. The wolverine or glutton is found in the north. The lynx (*Lynx vulgaris*), whose beautiful spotted skin is mentioned as a princely adornment in the German epic of the Nibelungen, still has its home in Norway. The wild cat (*Felis catus ferus*), wolf (*Canis lupus*), fox (*Canis vulpes*), and otter (*Lutra vulgaris*), are widely distributed. The family of the marten has seven representatives distributed through every part of the region, the rock or house marten (*Mustela foina*), the tree marten (*M. martes*), the pole-cat (*Fœtoris futorius*), the ferret (*F. furo*), the weasel (*F. vulgaris*), the ermine (F. *erminea*), and the lesser otter (*Putorius lutreola*). Among the characteristic and as a rule widely distributed rodents are the beaver (*Castor fiber*), now almost extinct in Germany, the migratory rat (*M. decumanus*) which only reached Europe from the Volga in the year 1727, and drove out the brown house rat (*M. rattus*), the mouse (*M. musculus*), the water rat (*Hypudæus amphibius*), several kinds of field mice, the lemming (*Myodes lemmus*), a native of Scandinavia, the hamster (*Cricetus frumentarius*), the dormouse (*Myoxus glis*), a rat-like animal that the Romans fed in particular enclosures, the hazel-mouse (*Muscardinus avellanarius*), the alpine marmot (*Arctomys marmota*), the zisel (*Spermophilus citillus*), and the squirrel (*Sciuris vulgaris*). The wild boar (*Sus scropha*) is the representative of the bristle-bearing animals. First among the ruminants is the reindeer (*Tarandus rangifer*), which inhabits the mountains of Scandinavia, Lapland, and Finland, the elk (*Alces palmatus*), once an inhabitant of Germany, but now restricted to the Baltic provinces of Russia, and to Norway and Sweden; the fallow deer (*Dama vulgaris*), probably an immigrant from the



BISON. Length, 10 to 11 feet.

Mediterranean region, the red deer (*Cervus elaphus*), the roe (*Cervus capreolus*), the chamois, which we have already mentioned, the ibex (*Capra ibex*), and lastly the bison (*Bos bison*), the largest mammal of the European continent, now only to be found in its imperial home the Lithuanian forest of Bialowicza.

The number of seals and whales found on the coasts is very great. Seven varieties of the former have been noticed, among them the phoca or sea-dog (*Phoca vitulina*), the crested seal (*Stemmatopus cristatus*), and walrus (*Trichecus rosmarus*); of the latter, eleven dolphins, with the common dolphin (*Delphinus delphis*), the porpoise (*Phocæna communis*), the orc (*Hetero dondiodon*); the narwhal (*Monodon monoceros*), the spermaceti or white whale (*Phyoster macrocephalus*), two fin-fish (*Balænoptera longimana* and *boops*); and lastly the whale (*Balæna myshicetus*).

The bird world is singularly rich and varied; it comprises nearly 500 species, of which about 277 are also found in Germany; but perhaps the region does not contain one exclusive kind, and only very few are unknown in he adjoining countries, and that because the most familiar and most numerously represented kinds are birds of passage. The most characteristic are, according to Wallace, the thrush (*Turdus*), bush warbler (*Sylvia*), the reedling (*Panurus*), the tits (*Parus*), the pipits (*Anthus*), and the wagtails (*Motacilla*); which are all of them probably more numerous here than in any other part of the world; next to these the buntings (*Emberiza*), the snow buntings (*Plectrophanes*), house sparrows (*Passer*), crossbill (*Loxia*), linnets (*Linota*), magpies (*Pica*), grouse (*Tetrao*), and ptarmigan (*Lagopus*). Less characteristic, but still full of interest, are the vulture, eagle, falcon and owl tribes; ravens, swallows, shrikes, larks, woodpeckers, kingfishers, doves, bustards, herons, and storks (*Ciconia alba*), the ruff (*Machetes pugnax*), gulls, divers, wild duck, wild goose,

HERON (*Ardea cinerea*). Length, 40 to 42 inches.

eider duck (*Somateria mollissima*), and many other kinds too numerous to mention. Generally speaking, the northern limit of the oak woods forms a climatic boundary for many kinds of birds, and it must not be forgotten that as we advance southward the number of aquatic birds greatly diminishes, and that of land birds proportionately increases.

There are no kinds of reptiles peculiar to the sub-region. Turtles are scarcely represented at all; snakes and lizards are comparatively rare, the former possessing about fourteen, and the latter twelve, kinds. The ringed adder (*Tropidonotus natrix*) extends to Norway and the north of Russia; the most northern of all the snake tribe is, however, the viper (*Pelias berus*), which is found in Scandinavia as far as lat. 67°, and in Russia, at Archangel, at 64°. Of lizards, the sand lizard (*Lacerta stirpium*), has the greatest extent of distribution northward, it is found up to Poland, and the region of the blind-worm (*Anguis fragilis*) extends almost as far.

Amphibia are well represented. The proteus (*Proteus anguineus*) is exclusive, being only found in the underground lakes of Carniola and Carinthia. The male of the frog (*Alytes obstetricus*), a native of Central Europe, carries the eggs about with him till the young ones creep out. The brown frog (*Rana temporaria*) is found up to the extreme north; and the glistering toad (*Bombinator igneus*) and tree frog (*Hyla arborea*) are both common. The frog tribe push considerably further northward than the numerous and widespread salamanders, with the water salamander (*Triton cristatus*) and the fire salamander (*Salamandra maculata*).

Of fresh-water fishes, the region contains two peculiar varieties, the *Percarina*, found only in the Dniester, and a perch (*Aspro*), restricted to the rivers of the basin of the Danube; the latter kind includes the *aspro vulgaris* and the *aspro zingel*. Among the specially characteristic forms Wallace includes the sticklebacks (*Gasterosteus*), perch (*Perca*), chub (*Acerina*), and pike (*Lucio perca*), shad (*Silurus*), pike (*Esax*), carp (*Cyprinus*), gudgeon (*Gobio*), whiting (*Leuciscus*), tench (*Tinca*), bream (*Abramis*), bleak (*Alburnus*), and groundling (*Cobitis*), so that the families of the stickleback, perch, shad, and carp appear to be distinctive of the region. The sturgeon tribe is at home in the great rivers of the Black and Caspian Seas, represented by the (*Acipenser sturio*), sterlet (*A. ruhenus*), and the great sturgeon (*A. huso*), whose spawn comes into the market as caviar, and from whose large swimming-bladder isinglass is obtained.

No species of butterfly is absolutely restricted to this region, but several are characteristic of it. The *Doritis*, with the Apollo (*D. Apollo*), the yellow butterfly (*Colias*), with the lemon-coloured (*Rhamni*), the golden, (*Melitæa*), the flecked variety (*M. cinxia*), the tortoise-shell (*Argynnis*) Vanessa, painted lady (*Cardui*), Atalanta, peacock (*V. jo, V. antiopa, V. polychlorus, V. urticæ*, and *V. album*); the *Limnetis*, *L. populi*, the *Aporia*, and *cironabas* are all of them numerously and widely represented.

The region is rich in beetles, especially in *Carabidæ* and *Staphylinidæ*, brilliant metallic beetles (*Buprestidæ*) are scarce; *elateridæ* more numerous. Among *Malacoderms*, *Telephorus* and *Malachius* are characteristic, and the long-horned beetles (*Longicornia*) and *curculionidæ* are equally numerous and distinctive. Locusts are often a pest, especially in the south-east. Of the lower animal forms we may mention a few on account of the service which they render to us. The river crab (*Astacus fluviabilis*) is distributed throughout the whole region; of his gigantic kindred found in the seas, the lobster is known on every coast of Europe, the langouste (*Palinurus vulgaris*) is found in the Mediterranean, and near the coasts of Great Britain. Rich in variety of species is the family of the garnel, with the prawn, shrimp (*Crangon vulgaris*). Among worms, the valuable leech may be mentioned, whose different species belong to all the southern parts of the region. Of the mollusca, the snail shell (*Helix*) is well represented; the mussels including among their principal varieties the oyster (*Ostrea vulgaris*), *Mytilus edulis*, and the fresh-water pearl shell (*Unio margaritiferous*). We must refrain from entering more into detail concerning this part of the fauna which is so full of interest to the zoologist, since the lower organisms of the animal world are not sufficiently prominent to lay claim to a larger space of our present book.

CHAPTER VII.

ORGANIC LIFE OF THE OCEAN.

A detailed account of the organic life of the ocean will scarcely be expected from a geographical manual, but it would be unjustifiable to leave the subject altogether untouched, especially in reference to the southern oceans, where countless coral reefs and islands owe their existence to the combined labours of immense numbers of living animals.

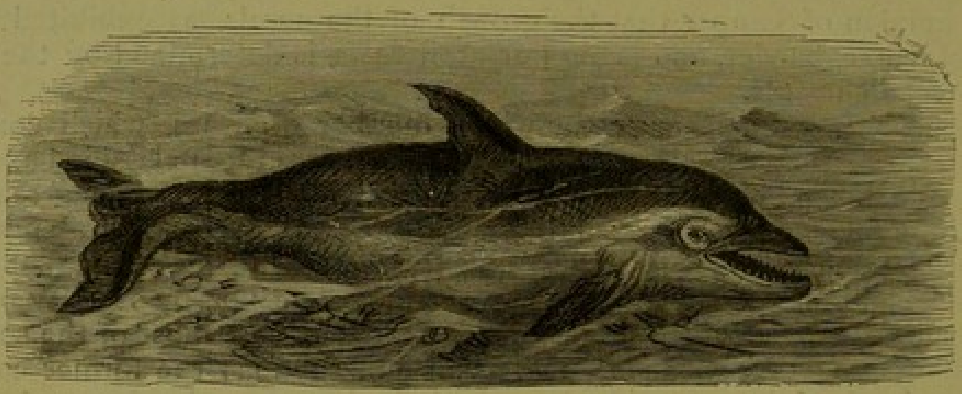
The true method of regarding the origin and formation of coral reefs, as laid down by Darwin and Dana, has been considered more at length in the earlier portion of this work; and we may add to our previous remarks that it is the opinion of Semper that the growth of the corals, as exhibited in the forms of fringe, barrier, and lagoon or atoll reefs, is determined by the action of the ocean currents.

Almost three-quarters of the whole number of fishes, which comprises about 6,000 species, are salt-water fish. As birds are often classified according to their domicile, in constant, periodic, and migrant birds, so may the world of fishes be divided into three similar classes. Carp, tench, and pike are constant or stationary fish, which never quit the waters in which they first issued from the egg, unless compelled to do so by an enemy or by scarcity of food. The case is different with herrings, haddock, roach, and most of the sole and plaice tribes, together with sturgeon, shad, and salmon; the former come up from the depth of the sea to the bays, and the latter wander far up the great rivers, both kinds falling victims to their inexorable enemy, man, who arrests them in their pilgrimage, and claims them for his welcome booty; the former may be considered as periodic, and the latter as migratory fish. There are also other kinds of migratory fish; the bonito, or striped tunny, for example, which is said by fishermen to come in shoals every year from the Atlantic to the Mediterranean; and the naturalist Brehm confirms the assertion, with the qualification that the Mediterranean harbours the tunny from one year's end to another; and all travellers and seafaring men are familiar with the bonito, which accompanies the tunny, and follows the ship across the ocean, as if it were his guide to shew the way. From the poles toward the equator the fish world decreases considerably, both in brilliancy of colour and marking, losing many of its grotesque and varied forms, and diminishing in the number of species, if not of individuals.

Each species of fish has its own area of distribution, distinct, although not sharply defined; the limits for the sea fish being probably determined by the temperature of the water. Prickly finned fish are the most numerous at the equator, and decrease towards the poles, as the soft-finned increase; so that, for instance, the number of herrings, cod, and salmon is greater in the north than in the south. The Old World, according to Agassiz, seems to possess no species originally common to itself and to North America. The sturgeon genus belongs to Europe and Western Asia. While the sturgeon family is distributed throughout the whole northern hemisphere, carp and loach are found almost exclusively in the eastern, and shad is common to both hemispheres. The Mediterranean, when compared with the Baltic, is rich in exclusive species, but in comparison to the northern seas it is poor in soles, plaice, and shell fish. The Red Sea has many species in common with the coasts of Madagascar and the Indian Ocean, and the latter has kinds common to the China seas. Many fish are restricted to sharply defined districts; for instance, the *Acerina Schraetzer*, a kindred form to the perch, is found only in the basin of the Danube, the *Comephorous baikalensis*, which in many respects resembles the mackerel, is never known beyond Lake Baikal, or the electric eel out of South America.

The cosmopolitan fishes are the eel, salmon, herring, bonito, common shark, saw-fish, etc.

Among fish, as among plants, we find representative vicarious forms, many of which are as yet but little known; the sea-cat, or king of the herrings (*Chimæra arctica*), for example, is replaced in the South Pacific by the *Calorhynchus* and *Arcticus;* and among the glittering scaled fish, the European and west Asiatic sturgeons (*Acipenser*) are represented in America by the



DOLPHIN (*Delphinus delphis*). Length, 6 feet.

gar-fish, or bony pike (*Lepidosteus*), and the paddle-fish (*Spatularia*), and in Africa by the *Polypterus*.

It would require a special text-book if we were to write down in systematic order all the treasures of the deep, in the lower organisms; and yet the traveller, hurrying across the ocean in a rapid steamer, perceives but little of the great wealth of animal life in the ocean, even though he happen to be a naturalist. Marine phosphorescence, flying fish, dolphins, a shark, are probably all that will come beneath his notice.

According to some naturalists, the ocean is divided into ten kingdoms, as follows:—

1. *Northern Polar Sea. Kingdom of the Sea Mammals and Sand-hoppers* (Amphipoda).

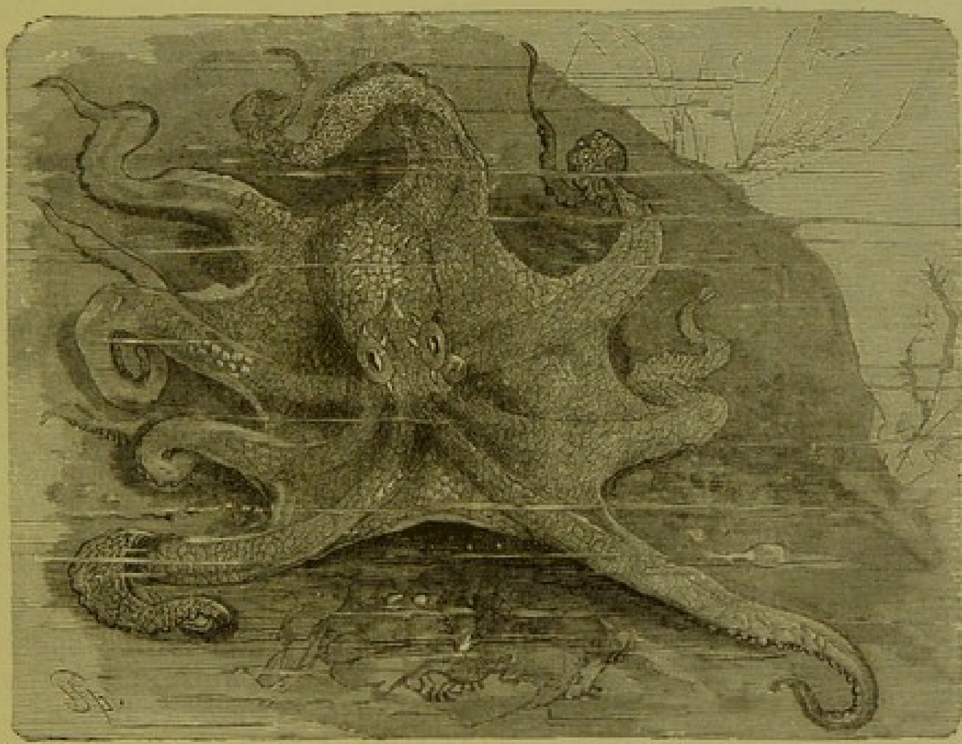
In these waters the great sea mammals, seals and whales, find their home. The numerous giant forms of the ocean find sustenance in the immeasurable numbers of individuals belonging to the lower forms. The walrus and narwhal are found nowhere else but in this kingdom.

Among crustacea, sand-hoppers and whale lice are the principal kinds; they devour dead and putrid substances, and so represent the numerous insect forms which perform the same office on land. Crabs already disappear near

Newfoundland. Worms are numerous, as also are mollusca, the prevalent forms having a typical character of their own.

2. *Antarctic Seas. Kingdom of Sea Mammals and Penguins.*

A great part is played in these waters by the sea mammals. Birds are represented in large numbers by penguins, which may fairly be reckoned among the denizens of the seas, as they cannot fly, and are found up to 70° lat. S., swimming nine hundred miles from land. They only visit the islands and mainland of America to breed. Lower organisms of sea creatures are found in great numbers, their development being favoured by a peculiar marine vegetation, especially the giant sea grass, almost every leaf of which is covered with limpets, spiral and shell-less snails, sea urchins, sea stars, worms (*Planaria*), which in their turn are devoured by fishes, cuttle fish, and crabs.



OCTOPUS (*Octopus vulgaris*).

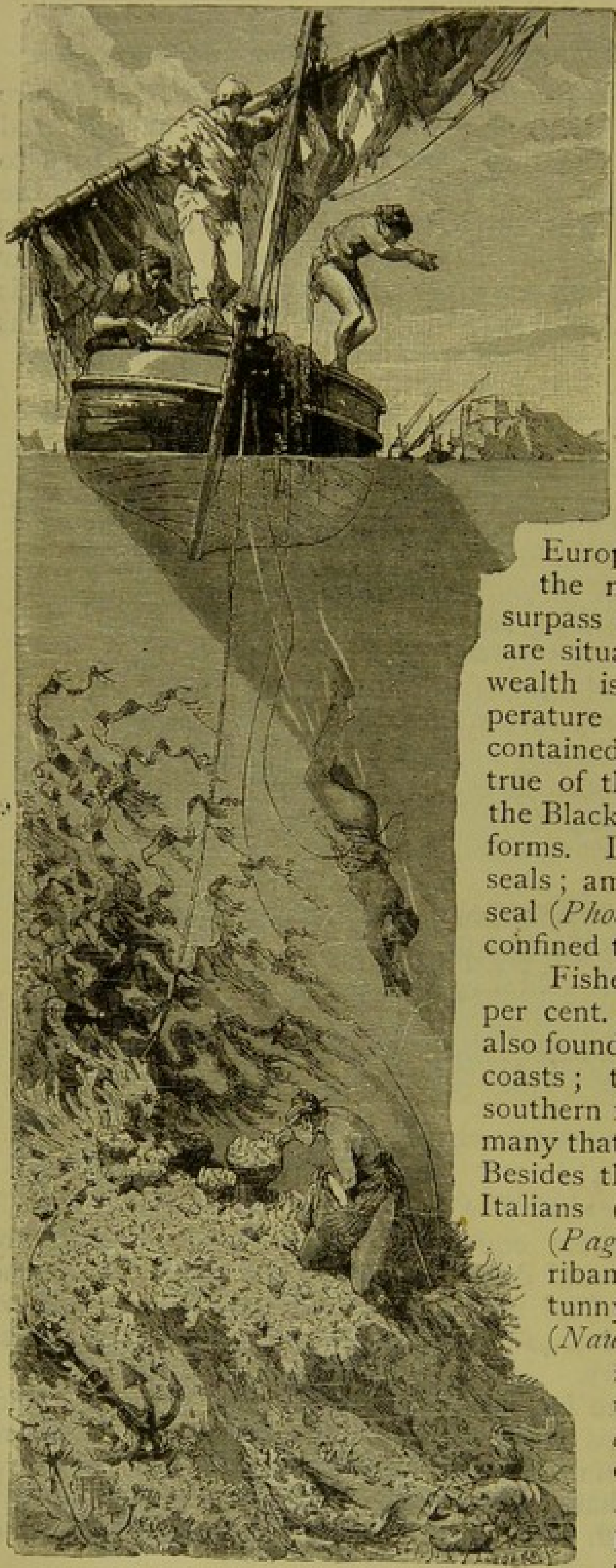
3. *North Atlantic Ocean. Kingdom of Shell Fish and Herrings.*

Between Iceland and the great equatorial current, sea mammals are everywhere represented by seals and dolphins, and by the deadly foe of the whale, the orc (*Orcinus orca*). The white or spermaceti whale (*Physeter*) does not go northward beyond lat. 42°, and the Greenland whale advances no further southward than Madeira.

The prevalent fish forms are herring, haddock, together with cod and torsk. The high northern groups of salmon and bull-head (*Coltus*) are here accompanied by sea perch, bream, and numberless mackerel. Gobies are numerous; as are also eels, sharks, and roach, while other families are sparingly or not at all represented. Towards the south the cod disappear and the mackerel increase.

Crustacea are here more variously represented than in the north, although several species of crabs, among them *anomura*, hermit crab, and sea locust

(*Squilla*), are altogether wanting, and the arrow-tailed *Xiphosura* only penetrates to lat. 40°.



Diving for Sponges in the Levant.

The mollusc fauna increases in numbers, and already on the south-west coast of Scandinavia there live nearly 350 varieties. The Baltic is an exception to this statement, for the mollusc fauna of its waters is unusually poor, and in the centre of the Gulf of Finland wholly loses its marine character. The species found in the Canaries corresponds entirely with those of the Mediterranean.

4. *Mediterranean Sea. Kingdom of the Labrus* (Wrasse).

The inland seas of southern Europe are not only much richer than the north European waters, but even surpass those parts of the Atlantic which are situated in the same latitude. This wealth is explained by the higher temperature and the greater amount of salt contained in the waters. It is especially true of the western basin; the eastern half, the Black Sea, being much poorer in animal forms. Dolphins are more numerous than seals; among the latter class is the monk-seal (*Phoca monachus*), a species exclusively confined to these waters.

Fishes are numerous, nearly thirty-five per cent. of the six hundred species being also found in the Atlantic and on the English coasts; the rest are composed of more southern forms, with some tropical ones, and many that are peculiar to the Mediterranean. Besides the bream family, the *Orada* of the Italians (*Chrysophrys aurata*), sea bream (*Pagellus centrodontes*), are found the riband-fish (*Cepola rubescens*), mackerel, tunny (*Thynnus vulgaris*), thornback (*Naucrates ductor*), sea urchins (*Echeneis remora*), sun fish (*Zeus faber*), umber (*Sciæna aquila* and *umbrina cirrhosa*), mullet, *Ramado* of the Italians (*Mugil capito* and *Mugil cephalus*), gudgeon, sea-pike (*Merlucius vulgaris*), and a great number of wrasse, which compose one-seventh of all the Mediterranean varieties, among them the *Labrus mixtus*, *Crenilabrus melops*, *Coris julis*, and parrot-fish (*Scarus cretensis*).

Among the mollusca (500 snails and 230 mussels), the principal representatives of the latter are *pectini branchia*, which exist in more than 100 varieties. Remarkable also are the purple snails (*Purpurea hæmastoma*, *murex brandaris* and *murex trunculus*). Sea stars (*Astropecten*) are numerous; among the polypi, the red coral (*Corallium rubrum*) is characteristic, and the bath and toilet sponges (*euspongia*) are of great importance. They are obtained by divers armed with a pronged fork, who find them on the coasts of Syria, Crete, and the Cyclades, as well as of Dalmatia and Istria. Our illustration represents the far-famed cephalopod, *Octopus vulgaris*.

5. *North Pacific Ocean. Kingdom of the Trigloidei* (Gurnards).

In addition to the mammals found in the same latitudes in the Atlantic, we find here the sea otter and sea lion. The sea cow (*Rhytina stelleri*), which was common as recently as the middle of the preceding century, is now extirpated. Fishes are but little known, but the gurnards predominate.

6. *Tropical Regions of the Atlantic. Kingdom of the Manatee and Plectognathi.*

In those parts of the Atlantic Ocean in which the temperature of the water does not sink below 68°, the mammals appear in altered proportions. There are fewer whales, and more dolphins and spermaceti whales. The plant-eating *manatees* are exclusive to these waters. Distributed with tolerable uniformity throughout the whole region are the little black storm bird (*Thalassidroma pelagica*), and the storm swallow (*Procellaria pelagica*). Among the fish are found wrasse, mackerel, tunny, the bonito (*Thynnus pelamys*), umber, scaly-fins (*Squami pennes*), sea hedgehog (*Diodon hystrix*), sun fish, swimming head (*Orthogoriscus mola*), and trunk-fish (*Ostracion quadricornis*).

7. *Indian Ocean. Kingdom of the Buccinida, or Whelks.*

The manatus of the Atlantic is here replaced by the siren (*Halicore*). Several species of dolphin are found; and whales are represented by the spermaceti and other kinds, which reach these waters in their wanderings from the southern arctic seas.

The great number of the sea snakes deserve attention; they are found swimming to and fro in hundreds, and three-fourths of all the known species are found here.

The varieties of fish, excepting the salmon and cod tribes, is very great, and has been estimated at 2,500. *Chætodon siluridæ* and electric fish (*Torpedinæ*) are very numerous. Purely Indian species (among others) are *Chelmo longirostris* and *Toxotes jaculator*.

The coasts of the Indian Ocean from the Red Sea to New Guinea are the richest in the world for crustacea. No less abundant is the wealth of molluscs. More than 2,500 sea molluscs are known on the Philippines. Among its cephalopods, the Indian Ocean has, in common with the Pacific, the nautilus, the only remaining representative of the great tribe of *Nautilidæ* of the prehistoric world.

Among snails, *Buccinidæ* are numerously represented; 250 species of *Mitra*, 100 of *Pleurotoma*, and the same number of *Conus* are known. The latter species are particularly characteristic; only five per cent. of their number being found beyond the Indian Ocean. Characteristic also are the *Cypræidæ* and the cowry shell (*Cypræa moneta*). The principal mussels are the giant mussel (*Tridacna*), the valuable pearl shell, the singular *Aspergillum*, and many others.

Of sea stars one half, and sea urchins one-third of the forms are purely

Indian. The corals are richer in number and variety than in the West Indies, but inferior to the coral wealth of the South Sea. Three-elevenths of the total number are found here. Reefs appear in each of the three principal forms—fringe, barrier, and atoll.

8. *Tropical Zone of the Pacific Ocean. Kingdom of Corals and Holothuriæ.*

A busy animal life prevails among the countless islands lying between the twentieth degrees of north and south latitude. Seals which abound in the tropical Atlantic, and are probably not to be found in the Indian Ocean, reappear within these waters; although we miss the plant-eating whale of the above-mentioned oceans. There is no lack of dolphins and large whales, the latter being so numerous round some of the South Sea Islands at certain times, that the whaling expeditions to these seas have of late often proved lucrative. Sea snakes are not so abundant as in the Indian Ocean. The fishes are but imperfectly known: while some species are widely distributed, others seem to be restricted to the shores of certain islands. That their numbers must be very great is proved by the presence of the sharks, with which the waters actually swarm, round several of the coasts.

In its brachiopods and cephalopods, the Pacific Ocean has much in common with the Indian: while its wealth in trepang (*Holothuriæ*) and corals is proportionately greater; two-fifths of all known corals being found here, or, in other words, the region contains almost as many species as the East and West Indian Oceans together. The reefs are found in all their three forms, except upon the South American coast, where an ocean current flowing from the south is unfavourable, from its low temperature, to the life of the reef-building corals.

9. *Southern Districts of the Atlantic Ocean.*

The high seas are poor in animal life. They contain, it is true, several peculiar forms of mammals; the elephant seal (*Cystophora probocidea*), the sea leopard (*Leptonyx leopardinus*), and the giant whale (*Sibbaldius borealis*), but no new types. The coasts exhibit a number of shell-less molluscs, and others with brilliant shells.

10. *Southern Parts of the Pacific Ocean.*

Neither the sea mammals nor the fish present any special characteristics; but, as far as our scanty knowledge of the latter allows us to form a decision, they are different from those of the northern hemisphere in species, and some of them in genus. A few isolated tropical forms are found round New Zealand and Tasmania.

The great luxuriance and diversity of animal and vegetal life which is to be seen on most ocean coasts is not, as a rule, restricted, as was formerly believed, to an inconsiderable depth, but extends in undiminished fulness to at least 300, and in many cases to 450 or 600 yards below the surface. The plant life, so richly represented in the first 150 yards by the varied forms of algæ, appears at a depth of 300 yards to decrease greatly, both in varieties and in the number of individuals. In depths of from 375 to 475 yards it is very scantily represented, and certain isolated lower forms of weed seldom descend below 625 yards. Animal life, on the contrary, extends to at least twice this depth, and is found in considerable wealth of forms even below 950 yards.

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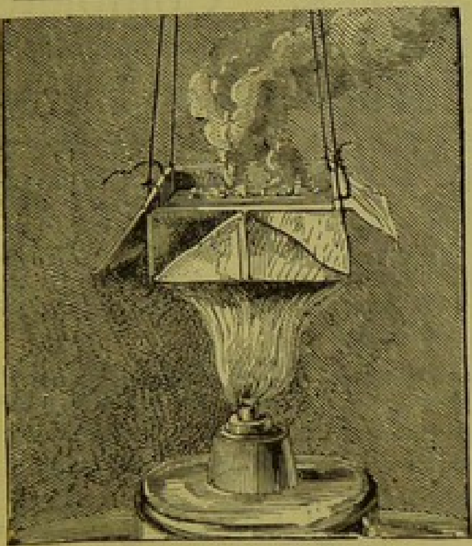

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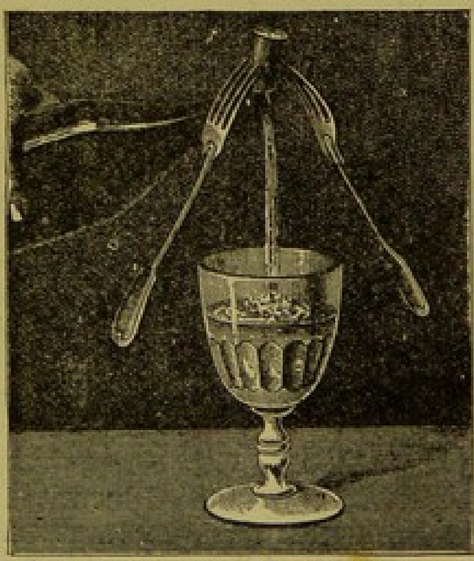

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