Past and Future

L. W. G. Malcolm

Dr. R. Shingleton Smith

from his old friend

[illegible]

17 Nov. 1892.

PAST AND FUTURE

PRESS NOTICES OF THE FIRST EDITION.

"The 'Ape and Man' question is treated with lucidity, a quality noticeable in the book, and is extremely productive of reflection. Mr. Jessop speaks of gaps in biological history, and this chapter, well reasoned as it is, 'inferentially' hints at one between apes and talking men."—*Spectator*.

"This book has considerable merits. The author has gone to the best authorities: he writes clearly, and generally with commendable simplicity; and a good many of his speculations afford abundant material for thought. . . . A notable production."—*Morning Post*.

"Contains much information, and indicates that the author has read widely and has displayed unusual industry."—*Westminster Review*.

"The author describes in clear popular language the solar system, the five, geological periods of the earth, climate, the life-kingdom's local development, surplus organs, the antiquity of man, passions and intellect, the known and the unknown, and primitive religion."—*National Observer*.

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PAST AND FUTURE

BEING A SECOND EDITION, WITH ADDENDA, OF

SATURN'S KINGDOM

OR

FABLE AND FACT

BY

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"Vive memor Lethi: fugit Hora: hoc quod loquor inde est"
PERSIUS, *Sat.* v., 153

"Live mindful of thy Life's oblivion;
Time wanes, it flees apace: the word I speak
Consumes its instants and contracts its span"
T. J.

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PREFACE TO SECOND EDITION.

THERE is scarcely a man, woman or child in any country in the world possessing a national religion of some kind who does not believe that a Soul or Spirit is resident within the body, but whence this Soul comes or whither it goes is a matter of obscurity to all, and even of indifference to some.

The terms Soul, Life and Spirit as applied to Animal Life by ancient as well as by some modern Authors seem to be interchangeable terms; at present they are differentiated into Life, a possession common alike to the Vegetable and Animal Kingdoms, and Soul or Spirit, a something superadded to animal life. The Soul may be considered as an appendage to a living form and the term Spirit to this Soul when deprived of its carnal abode.

In the following pages, by describing physical occurrences in the past, I have endeavoured to trace the succession of events which ultimately lead to the origin of Soul and its distribution in the human race. Briefly, the Soul is an internal power; called into being by and through maternal influence, it grows *pari passu* with the growth of the body in a perpetual progress of improvement, that is, its growth is slow but regular and orderly. If reared thus healthily or in goodness—by goodness I mean subordination of self—it will become an immaterial definite shape, pervading, hovering over and controlling the visible shape which it uses as a tenement; and this immaterial shape may and most probably does come into contact with occult influences which produce or direct thoughts and actions. On the other hand, if this internal power is not so reared it either dwindles or grows too fast, *i.e.* the mental and bodily growth do not coincide, proportion is lost and formative power is degraded; it will have no shape, nor will it have control over the actions of its more slowly growing tenement, which tenement will then only be guided by instincts derived from the wants of its animal form.

This idea of the birth of Soul is forced upon us from the consideration that the sense of touch is the earliest manifestation of any one of our five senses, and that from which we derive our first impressions of material objects; for the organs of taste, sight, hearing and smell are not at the disposal of the Infant at birth; hence the sense of touch is its only organ of communication with other beings, and that communication is and must be gentle in character. In this way will spring up between Mother and Infant a subtle influence to which we give the name of Soul—an internal power, intelligence, bond of union or unexpressed interdependence. By slow stages this influence is transferred through the organs of taste, sight, hearing and smell to centres in the brain in communication with the intellectual centres. Just as a spark excited by the friction of two pieces of wood, if caught in tinder, may be transferred to other substances, or for want of care it may be lost.

The sense of touch may be termed the language of Infancy, which declines gradually in importance as the remaining senses become developed and the faculty of speech established. Immediate contact is no longer required, for government henceforth proceeds through the understanding. It seems hardly necessary to say that if gentleness in infancy, before understanding is developed, is essential to the well-being of the body, it is still more necessary as the understanding is unfolded. Hence the development of a Soul demands unwearied care and supervision from parents and teachers. It is a tender plant and not able to withstand rude mental shocks such as are given in the contemplation of everlasting bliss or unutterable woe. The former it cannot comprehend, and the latter is terrorism of an odious kind on a par with that of shutting up a child in a dark closet, or teaching it docility by the aid of a phantom. As a child such matters revolved in my mind, and what I thought, every child knows who has thought on such subjects. It seemed to be an inconsistent and intolerable absurdity to suppose that the human race was created for the purpose of peopling heaven and hell;* and that a portion of a holy spirit should be subjected to reward or punishment according to its ability or inability to cope with or control the natural instincts necessary for the welfare of the creatures of the universe, only a fractional part of which possesses a sufficient amount of brain-matter to enable it to take cognizance of a holy spirit. Such a supposition seems to negative the wisdom of God and to make him the indirect Author of Evil. I fail to understand how such a dogma can promote either religion or morality.

But, on the supposition of Soul being generated under maternal influences, parents will realize that *they* and not the Creator are responsible for the good or evil inclinations which increase or decrease earthly happiness. With them also will rest the doctrine of immortality for their offspring, and the means to this end are not only the inculcation but the *practice* of belief, truth, and brotherly love. This doctrine of

* See an excellent article on the Hebrew Hell in the *Nineteenth Century* for August, 1890.

immortality, nearly three thousand years before the time of Abraham, was the creed—a settled creed showing that many ages had elapsed before it was the settled creed—of the Egyptians, of whose origin as cultured inhabitants of the world we have no record. These carefully embalmed their dead in the hope that the Soul would again inhabit its earthly home and be reunited in a literal resurrection of the body. This creed appears, however, to have become corrupted and fell into desuetude till it was revived as a fundamental doctrine of the Christian faith.

In the following pages I have ventured to submit some theories for the consideration and criticism of those who are concerned with the instruction and treatment of children and of those creatures which minister to our wants or pleasures, whose bulk may be on a par with that of Man, but whose intellect only equals that of a child two years of age. At the outset Soul was defined to be an internal power called into being by maternal influence. On the supposition that animal forms below the rank of Man—and in many cases even Man himself—in consequence of deficient brain capacity are only capable of developing this internal power to a limited extent, we shall thus have a higher and lower degree of this power. In this way we can reconcile the views of those who believe that the inferior animals have Souls. But for the higher expression of this characteristic, cultivated Man alone has the power. Of course each degree has many grades of cultivation.

Animals can be and are trained to reciprocate affection towards those who treat them well, but that is all—out of sight out of mind is their condition. Yet memory in some animals may be revived when they see and hear the form and voice once well known;* but this does not endow them with the higher degree of Soul.

The origin, then, of the psychical function is, on this theory, a question of degree, for until nervous elements became concentrated and developed in the Craniota, there could be no such function. But when once established, its growth would be in proportion to intellectual development. If trained in goodness, the soul apart from the body has a claim for a continuity of existence. But if allowed to grow wild, the higher degree is never attained, and its existence terminates on the death of the body.

This book has a physical, biological, and archæological character. To fully bring out this last quality it seemed desirable to give an outline of the constitution of the universe and the source of heat,

* After a lapse of seven years my Arab chestnut horse "Buffer" pricked his ears and turned his head on hearing my voice, affectionately evinced his pleasure when at his side, and looked wistfully after me as I left him. He was sold to me as an untameable, vicious brute. We soon became good friends, and I found him an excellent horse in every capacity.

in order that the effects of climate upon the production, retention, alteration, and diffusion of genera and species (vegetable and animal) should be clearly apprehended; and further to show that in the earlier ages of the world it was impossible for so highly organized a being as Man to exist, when the whole earth was enduring a temperature far in excess of the present tropical heat, yet that this very condition of high temperature was essential for the development of the lower and coarser forms of vegetable and animal life. But when the temperature of the earth decreased vegetable forms became stunted, animals dwarfed, and intellectual Man arose to assert his sway over and make use of these changed forms.

Hence the earlier chapters in this volume are not written for the purpose of teaching subjects in science, as many may suppose—for readers nowadays are mostly acquainted with recognized treatises, or at all events with magazine articles, on these subjects—but to show how the results of energy in the past are closely connected with our present condition and position in the universe and what these results may be in the future. Shortly, therefore, and accurately I hope, I have presented some interesting facts not generally thought of in connection with one another for the use of those who, though they would not—either for want of time or inclination—read a special work on any one subject, might nevertheless be induced to refresh the memory from one wherein physical facts, when shorn of detail, brought together and sympathetically treated, lead up to a conclusion in which mankind is interested.

Each chapter though distinct in itself is connected more or less with the rest to prove a general conclusion. Those who do not care for the scientific evidence on which the archæological portion rests, after reading the introduction can pass on to the twelfth chapter, which treats of surplus organs in the human body.

This volume was published at first under the title of "Saturn's Kingdom, or Fable and Fact," because it contains a brief account of things in heaven and things on earth over which the mythological god Saturn was said to rule, and also because this god (though probably now out of court) was the representative of Time, which is so large a factor in the world's progress. Those of my critics who took umbrage at the title will perhaps forgive me for having used one which was not descriptive of the contents of the volume. To atone for this want of perspicuity I have in this edition changed the title to "Past and Future." I trust, therefore, reviewers will be satisfied with the alteration, and accept the explanation.

Others, again, have taken exception to the introduction of what they are pleased to term the mythical Bathybius. This lowly form, though said to be disclaimed by its original discoverer, has not been relegated to oblivion by Professor Haeckel, nor can I see any reason for doing so. If any animal body can be reduced to its chemical constituents, surely that is no reason for asserting it never possessed life. So long, therefore, as Professor Haeckel believes Bathybius to be the lowest form in which life is or can be first manifested I shall for the reason above stated adhere to what has been said of it in the text.

To the present edition I have appended some observations on atmospheric and deep sea conditions which were omitted in the first issue; I trust they may be favourably received.

C. M. J.

SUTHERLAND AVENUE,
October, 1892.

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SATURN'S KINGDOM;

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CHAPTER I.

INTRODUCTORY.

In Mythology, Uranus or Heaven is married to Terra, or Tellus the Earth; the former is the father by whose influence the Earth as mother furnished material for generation. The progeny of the union was numerous. Saturn, one of the sons, aided by his mother, rebelled against his father, and, by the consent of Titan, his elder brother, obtained the kingdom, provided he did not bring up any male child, in order that the throne should revert to Titan. Saturn espoused his sister Ops, or Rhea, and, in pursuance of his agreement, devoured indiscriminately all her children as soon as they were born. Rhea, disgusted with this cruelty, concealed the births of Jupiter, Juno, Neptune and Pluto substituting large stones which her husband at once swallowed without perceiving the deceit.

When Titan heard that Saturn had concealed the birth of male children, he made war upon him, and dethroned and imprisoned him with Rhea. Jupiter meanwhile was educated in a cave on Mount Ida in Crete. When grown to man's estate he delivered his father and reinstated him on the throne. Saturn became apprehensive of his son's power and unmindful of his kindness conspired against him. For this treachery he was driven from his kingdom; he sought refuge in Italy—called Latium, the place of his concealment (*lateo*). He was hospitably received by Janus the king, and made partner on his throne.

The declining years of the King of Heaven were employed in civilizing the barbarous peoples around him, teaching them agriculture and useful and liberal arts. His reign was so mild and popular, so beneficent and virtuous, that it has been called the Golden Age, to intimate the happiness and tranquillity which the earth then enjoyed.

Saturn was represented as an old man bent with age, gray and bare-headed, with a worn and ragged garment, a scythe, or sickle, and key in his hand, devouring his children, to denote the antiquity and long continuance of time. The gray hairs and bent back indicated the age to which men then lived; the bare head—that time reveals all things, for honesty and truth are naked, whereas falsehood and deceit are still covered; the ragged and worn garment—that time wears all things, pride and curiosity of apparel being unknown; the scythe, or sickle—for the mowing or reaping of corn, that time overtakes all things; and the key may denote that time opens and discloses all secrets, whilst the devouring of his children may signify that all compounded bodies are destroyed by time.*

Saturn, then, as the son of Heaven, is an emblem of time, because the *apparent* motion of the starry universe is a measure of time; and as the son of Earth, because the ebbing and flowing of the sea is likewise a measure of time.

Time is divisible into Past and Future. Time present only exists as a vanishing point, for time is the progress of instants, graphically expressed from the pulpit "The Future is Now." Our mental as well as bodily disposition is a record of time past. Thoughts good or evil, habits good or bad, are indelible. From infancy our mental faculties and corporeal framework have been, as it were, built up and become "ourselves"; we are, therefore, accretions of time. The moral is plain, the application universal.

With the ordinary modes of computing and observing time by clepsydræ—one still existing and in

* "Mystagogus Poeticus," by A. Ross, A.D. 1648.

working order at Canton—sun-dials, watches, clocks, wax tapers in lanterns used by Alfred the Great, tuning-forks, and the yearly calendar which describes what has happened and what is to happen in the astronomical point of view, all are familiar. But few persons trouble themselves with facts taking place slowly and imperceptibly around them, as measures of time in the gradual *denudation* of the earth's surface by the action of rain, snow and ice, and the swallowing up of the *débris* in the various oceans which surround the continents of the world, or the seas and lakes contained therein, and to what results this will lead and has led in the past.

Astronomers have familiarized the public with the vastness of space and the countless ages that have passed, by the length of time which is required to elapse before we can behold the light of distant stars. Light consists of the undulations or waves of a medium, called ether, which pervades all space. Waves of ether are set in motion by light and bodies at a high temperature. Light travels by these waves at the rate of 186,680 miles in one second of time, or a distance equal to eight times round the earth.

Stars are of different sizes or magnitudes. Up to the sixth magnitude they are visible to the naked eye; beyond that only by telescope. The average number of stars which can be seen by the naked eye is from four to five thousand; but Struve, by

Herschel's twenty-foot telescope, estimated twenty millions. With larger, modern telescopes probably between thirty and fifty millions.

The nearest star, α Centauri, is situated at such a distance that light requires three and a half years to traverse space. From a star of the first magnitude light takes fifteen and a half years to reach this earth.* From a star of the second magnitude light takes twenty-eight years; from a star of the sixth magnitude, one hundred and twenty years; from one of the twelfth magnitude, three thousand five hundred years; and from still more distant stars just visible with the most powerful telescopes fifty thousand years. New stars are constantly being discovered because our whole solar system is progressing forward into space at the rate of $33''\cdot9$ per century, says Struve, or according to Dunkin, $33''\cdot5$ or $41''\cdot0$ per century. The sun, says Herschel, advances through space, carrying with it the whole planetary and cometary system with a velocity of 1·623 radii of the earth's orbit, or 154,185,000 miles *per annum*, or 422,000 miles *per diem*.

The seven figures (1,000,000) which stand for one million convey to the mind no idea of the magnitude of one million. But if we take a tape, as suggested

* Fifteen and a half years equal 488,808,000 seconds; multiplied by 186,680 (the number of miles light travels in a second) equal 91,250,677,440,000 miles distance.

by Mr. Croll, of 83 feet 4 inches long and divide it into tenths of an inch, each tenth representing one hundred years, this tape extended will convey some idea of the enormous amount expressed by the word "million." Or if we adopt Mr. Nasmyth's ingenious device—arrange types in one large sheet—a better idea still is conveyed. He thus arranged sixty columns of ordinary type of the *Times* newspaper some years ago for the benefit of shareholders of the Great Western Railway Company, in order to represent one million passengers. Either plan is significant—the one, perhaps, of distance; the other of multitude.

Recently I constructed such a sheet from columns of the *Morning Post*. Oddly enough, when the sheet was completed there was a blank space of about twelve inches at the end of a column, which would correspond very nearly with the amount of type required to express the age of the historical world. The insignificance of our history in comparison with one million years and the duration of time was thus graphically portrayed.

CHAPTER II.

THE SOLAR SYSTEM.

THE sun is a star and the centre of a system consisting of planets, comets, meteors, and a ring of nebulous matter revolving round the sun, nearly in the plane of the ecliptic, and filling up the space between the sun and earth. The zodiacal light is probably due to sunlight reflected from this immense cloud of meteoroids.

The sun himself is supposed to be an incandescent gaseous mass, and the combustion now going on in this mass will, it is thought, in time produce rock-like substances similar to those on the earth.

The outer envelope of the sun is considered to be burning hydrogen commingled with the vapours of thirty-two metals and two non-metallic elements. These substances have been discovered by aid of the spectroscope.

The spectroscope has also been used for analysis of the composition of the fixed stars and nebulæ. "According to Mr. Lockyer, those stars which have the highest temperature have the simplest spectra and in proportion as they cool their materials become more and more differentiated into what we call simple elements. He remarks that the most brilliant or hottest stars show in their spectra only the lines of gases as hydrogen. Cooler stars, like our sun, give indications of the presence, in addition, of the metals—magnesium, sodium, calcium, iron. A still lower temperature he regards as marked by the appearance of the other metals, metalloids, and compounds. The sun would thus be a star considerably advanced in the process of differentiation or association of its atoms. It contains, so far as we know, no metalloid except carbon and possibly oxygen, nor any compound, while stars like Sirius show the presence only of hydrogen with but a feeble proportion of metallic vapours; and on the other hand, the red stars indicate by their spectra that their metallic vapours have entered into combination, whence it is inferred that their temperature is lower than that of our sun."*

Origin of the Sun, Planets, and Meteorites.

The origin of the sun and his heat, shortly stated, is from the primæval potential energy of gravitation of the sun's particles.

Kant assumed that all materials out of which the bodies of our solar system were formed, were,

* Geike's "Text-book of Geology."

in the beginning of things, resolved in their original elements and filled all the space of the universe in which those bodies now move; the formation of separate bodies by mutual gravitation of parts of the mass being a later occurrence. Originally these particles of matter, produced at a distance from each other and endowed with the power of gravitation, formed a globular, chaotic mass of uniform density extending into space beyond the outermost planet—Neptune, 2,746,271,000 miles from the sun. This mass became detached from the nebulous balls of the adjacent stars and possessed a slow movement of rotation; and as the particles rushed together in condensation, rotatory movement increased, heat and light under the reciprocal attraction were generated.* Just as the potential energy of a falling stone is converted into heat—that is, the exact equivalent of heat is generated for motion lost in

* A body sensibly hot has its particles in an active state of motion. These particles have—if not in solids and liquids yet certainly in gases—six degrees of freedom; when they strike each other they not only rebound but they spin; to this energy of translation must be added rotation. Molecules are made up of atoms which are not stationary in them, but may be so violently agitated as to leave altogether giving rise to chemical decomposition by heat; part of the energy of a heated body is due to intra-molecular atomic oscillations. Lastly Ether entangled in a molecule is also set in vibration. The sum is found to be proportional on the average to the kinetic energy of translation alone. Heat is not motion nor change of position nor momentum but the energy of motion.—Daniell.

collision—so in times past smaller bodies of nebulous matter falling together by mutual gravitation produced the denser and central portion of what forms our present sun, in which is stored up light and heat for a series of ages.

Under centrifugal force, masses at the circumference of this enormous disc became detached to take on rotation as independent nebulous bodies in the direction of the original mass. They in time became repelling particles to masses at their periphery to form satellites. In another case the mass which separated from the outside of the chief ball would be parted into many fragments and form swarms of small planets, as seen between Mars and Jupiter.

The ring of Saturn is formed by a cloud of satellites too small to be seen in the telescope and too close together to admit of the intervals being visible. They are like little separate drops of water of which fogs and clouds are composed which to our eyes seem like solid masses.*

The meteorites, which wander loosely in space, are supposed by Helmholtz to have been formed by the gradual aggregation of "cosmical dust," a primitive condition of fine nebulous masses. At present, however, they are regarded as "the offspring of sidereal masses, and not their parents."† They

* Helmholtz. † Croll's "Stellar Evolution."

possess a planetary velocity of from eighteen to forty miles a second. When they come within the influence of a strongly resisting medium—our atmosphere—their motion is delayed; at the same time they are heated by increased friction, and at forty miles per second are consumed by the heat generated.* Many escape from the terrestrial atmosphere, and continue their path with an altered and retarded motion; others fall to the earth. As no meteor has been observed to commence at a height above one hundred miles, the atmosphere, it is thought, does not extend more than ten miles beyond, and this is double the height to which formerly it was supposed to reach. The outer crust of meteoric stones shows traces of fusion; the surface is hot, whilst the intense cold of cosmical space is manifested in the interior of detached pieces.

Each stone, according to A. Herschel's estimate, is 450 miles from its neighbours, and of these stones about seven and a half millions fall daily. The earth, which revolves in its orbit at the rate of 18·3 miles a second, sweeps, in round numbers,

* The least velocity with which a body could strike the sun is 280 miles per second, and if the body fell from an infinite height the velocity would be over 350 miles per second. A body moving through air at 125 feet per second raises a thermometer 1°. Hence the earth, moving in its orbit at 96,500 feet per second, would raise the temperature of any body at rest, as meteoroids, to 600,000° nearly: for $\frac{96500}{125} = 772^2$, which is 595,984°. Increase of temperature equals the square of velocity for higher velocities than 125 feet: 4° with 250 feet; 16° with 500 feet per second.—Helmholtz.

1147 millions of cubic miles of space every second, and carries with it whatever stones are contained therein—groups irregularly distributed in space and denser swarms which move in regular elliptical orbits. Certain comets accompany the paths of these swarms and give rise to the supposition that the comets gradually split up into meteoric clusters. What the earth does, other planets have also been doing for millions of years, sweeping together the loose masses in space and holding fast what they have attracted. Nordenskjöld, says Daniell, computes that the earth gains every year at least half a million tons. In the same way, the meteorites which fall on the sun must produce a flash of light, some heat and a thickening of the sun. It follows, therefore, that the sun and planets were once smaller than at present, their bulk having been increased by the appropriation of masses diffused in space.

The universe is full of two kinds of matter; one kind is visible as in the sun and stars, the other invisible to our senses but existing throughout the universe and in the interstitial spaces of all matter—it is called ether—and though very attenuated is of sufficient importance when considered in bulk to exercise notable effects on moving bodies. On the earth we are accustomed to regard our atmosphere by which we live as immaterial; but if we ascend high mountains or descend into deep mines our bodies become sensible of the difference due to the decrease or increase in the weight of the atmosphere. This proves that a material is present for which calculation must be made. So it is with ether outside our planet. Luminiferous ether, then, cannot be equal to zero. A volume equal to that of the earth, says Sir William Thomson, cannot contain less than 2775 pounds of luminous ether. Though this medium is too attenuated for mortal eyes to perceive any diminution in the motion of the planets from its resistance, yet with smaller bodies it is different. Encke has shown, that on comparing the intervals between the successive perihelion passages of the comet which bears his name, the periods are continually diminishing, or in other words the mean distance from the sun, or the major axis of the ellipse is dwindling by slow and regular degrees at the rate of about $0^{d}\cdot11176$ per revolution. This is evidently the effect which would be produced by a resistance experienced by the comet from a very rare ethereal medium pervading the regions in which it moves; for such resistance, by diminishing its actual velocity, would diminish also its centrifugal force, and thus give the sun more power over it to draw it nearer. It will, therefore, probably fall ultimately into the sun, should it not first be dissipated altogether—a thing no way improbable when the lightness of its materials is considered.*

* Herschel.

Such, briefly, is the theory of the origin of the planets of the solar system which revolve round the sun in one direction from west to east. The sun, the planets and their satellites also revolve on their axes in the same direction, with the exception of the satellites of Uranus, which revolve from east to west. The planets, their satellites, and the sun himself all have their axes of rotation inclined to the plane of the ecliptic.

The Sun's Heat.

The heat possessed by a body is explained as being the energy possessed by it in virtue of the motion of its particles; it is the lowest form of energy. It depends on undirected and blind activity of molecules which dart hither and thither. A white-hot iron ball is visible in a dark room but ceases to be so when its temperature sinks below 977° F.; *i.e.* it ceases to radiate light * because the waves are too slow to affect the eye, but the radiation of heat is continued.

* Light from incandescent solids or liquids travels from some distance within the surface; for it is polarized at right angles to the plane of incidence. This shows that it has been refracted on its outward passage through the surface of the incandescent body and into the rarer surrounding medium. Light from incandescent gases is not polarized; sunlight is not polarized; hence sunlight is due to incandescent gas or vapour. Sunlight is originally bright blue, and is extremely rich in the more refrangible rays; but filtration through two absorbent atmospheres—that of the sun and that of the earth—renders it a yellowish white.—Langley, quoted by Daniell.

The radiant heat from the sun falling upon a square foot of the earth's surface has been found to be 83·4 foot-pounds per second; and the amount radiated from a square foot of the sun's surface is to that incident on a square foot of the earth's surface as the square of the sun's distance to the square of his radius, or as 46005 * to 1. Hence 46005 * × 83·4 = 3,836,177 foot-pounds of heat radiated off every square foot of the sun's surface per second,† an amount equal to about 7000 horse power.‡ Of the total amount of heat radiated off the whole surface of the sun the earth receives but the $\frac{1}{2,138,000,000}$ part.

The radiant energy of the sun is not derived from combustion, for the sun would last but a comparatively short time if its energy were derived from any such source.§

The velocity acquired by which a body falling from space into the sun "would be equal to that which would be generated by a constant force equal to the weight of the body at the sun's surface operating through a space equal to the sun's radius."‖ One pound weight at the sun's surface weighs 28 pounds. The sun's radius is 426,292 miles. The energy of one pound of matter falling into the sun from infinite space

* New value. † Croll, "Climate and Time," ch. xxi.

‡ One horse power denotes a rate of working in which energy is evolved at the rate of 550 foot-pounds per second.

§ Daniell's "Physics."

‖ Croll, "Climate and Time," ch. xxi.

would equal that of a 28 lb. weight descending upon the earth from 426,292 miles, supposing the force of gravity to be as great at that elevation as it is at the earth's surface. It would amount to 63,023,009,280 foot-pounds.* Great as is this amount of energy it would not be a sufficient source for the continuous heat radiated from the sun. A mass equal to that of the earth falling upon the sun "would maintain the heat for only ninety-three years, and a mass equal to that of the sun falling into the sun would afford but ninety-three million years' sun-heat." † The above is an outline of the meteoric theory of the sun's heat.

The contraction of the globular chaotic mass which is supposed to have extended originally beyond the outermost planet implies work estimated in foot-pounds of heat sufficient for 20,237,500 years. ‡

* Obtained by reducing the radius of the sun into feet and multiplying by 28.

† Croll, "Climate and Time," ch. xxi.

‡ The formula for this sum is given by Helmholtz—

$$\text{Work of condensation} = \frac{3}{5} \times \frac{r^2 m^2}{\text{RM}} \times g.$$

M is the mass of the sun; m is the mass of the earth; R is the sun's radius; and r the earth's radius.

Taking $\text{M} = 4230 \times 10^{27}$ lbs.; $m = 11920 \times 10^{21}$ lbs.; $\text{R} = 2{,}328{,}500{,}000$ feet; and $r = 20{,}889{,}272 \cdot 5$ feet.

The total amount of work performed by gravitation in foot-pounds is—

$$\text{Work} = \frac{3}{5} \times \frac{(20{,}889{,}272 \cdot 5)^2 \times (4230 \times 10^{27})^2}{2{,}328{,}500{,}000 \times 11920 \times 10^{21}} = 168{,}790 \times 10^{36} \text{ foot-}$$

pounds, the amount of heat produced by gravitation, which would suffice for nearly 20,237,500 years.

With the present magnitude of the sun his whole diameter need contract but 220 feet a year to produce all the heat which he now radiates. This contraction will amount to four miles in a century.

A known principle of the contraction of gaseous bodies is, that the more heat such a body loses the hotter it will become. By losing heat it contracts, but the heat generated by the contraction exceeds that which it had to lose in order to produce the contraction. When the mass of gas is so far contracted that it begins to solidify or liquefy further contraction is a cooling process.

The rate of contraction to keep up the present supply of heat diminishes as the sun grows smaller, so that in five millions of years the sun will be reduced to half of its present volume. If he has not begun to solidify now it is likely he will then, and his heat soon after diminish. It is improbable that he can radiate heat for ten millions more of years; and in twelve millions of years the sun will be as dense as this earth.*

The above is an outline of the source of the sun's heat by condensation. But, as Mr. Croll observes, this is not sufficient to account for heat lasting not less than one hundred million years; it is not sufficient for the production of life on this globe, and is not so much as the impact of a sun's mass upon

* Helmholtz.

the sun. "There must be some other source of much more importance than gravitation." The foregoing theories assume that the original nebulous mass was not possessed of temperature which was only generated as it became condensed under the form of gravitation.

But any material substance in a gaseous state possesses intrinsic heat, originally imparted to produce this gaseous state, which it parts with on reduction to a liquid or solid condition. "In the case of air and all perfect gases cooling under pressure, about 234·5 foot-pounds of the original heat possessed by the gas are given out, while 95 foot-pounds are being generated by condensation. We have, however, no reason whatever to believe that in the case of the cooling of the sun the same proportion would hold true." It may have been greater, or it may have been much less. Assuming that 234·5 foot-pounds of heat will raise the temperature of air 1°, and 95·7 foot-pounds will overcome mechanical obstruction, there will then be a total of 330·2 foot-pounds required to raise air 1° C.; or to sink the temperature 1° C. Thus, 234·5 foot-pounds will represent the energy or heat the air previously possessed and 95·7 the energy or heat of condensation; or as 2·45 is to 1*.

* Hence 20,237,500 × 2·45 = 49,581,875, or in round numbers fifty millions.

Applying, therefore, this proportion in the present case and on the supposition of uniform density of the mass, the quantity of heat given out which previously existed as intrinsic heat, must have been 49,851,875 years' heat, making a total of 69,819,375 years' heat; * *i.e.* twenty million years of heat produced by gravitation added to fifty million years of heat which may be called intrinsic, or latent.

As thirty million years of heat are required to complete the hundred millions, on the hypothesis that the earth has existed so long, Mr. Croll asks what power could have communicated to the mass fifty million years of heat before condensation began to take place? The reply is that the sun's energy *may* have originally been derived from motion in space. He supposes two bodies each one half of the mass of the sun moving directly towards each other with a velocity of 476 miles per second; † by their concussion they would generate in a single moment fifty million years of heat, which would equal the present amount of the sun's radiation. If the velocity of two such bodies be 563 miles per second at the moment of collision, seventy million years of heat would be generated.

But the heating and expansion of the sun into a gaseous body after the original concussion means

* Croll.

† Two bodies at 476 miles velocity would possess 4149×10^{38} foot-pounds of energy in form of *vis vive;* the stoppage of their motion would convert this motion into heat.—Croll.

work against gravitation, and is equal to that performed by gravitation during his cooling and condensation. This quantity has been shown to be equal to twenty million years of heat. Hence the entire geological history of this globe would be comprised within one hundred million years.*

Rate of Cooling and Temperature.

The rate of cooling of the sun's mass is unknown. Some heat is generated by the influx of meteoric matter, the amount of which may compensate for loss by radiation. But the heat generated by the fall of meteors within the last two or three thousand years is insufficient to give the heat supply, because the matter in the zodiacal light and intra-Mercurial planets is certainly small; so that solar radiation probably is not compensated to any appreciable extent.

As the sun's substance is very much like the earth's, it might appear probable, that if the sun's mean specific heat were equal to that of water, he might cool $1\frac{4}{10}$° C. annually. Also, that his expansibility with heat might not differ from some terrestrial body. But the physical circumstances of the sun's mass being different from those under which terrestrial experiments are conducted render the condition of the substances of which it is composed, different also as to expansibility in volume and specific heat.

* Croll.

The work done by mutual gravitation between different parts of the sun's contracting mass would be equal to one-tenth per cent. in diameter or $\frac{3}{10}$ per cent. in his bulk, and this could not take place in less than twenty thousand years and therefore would furnish heat for that period. It is almost certain that the sun's mean temperature is not less than 14,000° C.; and this high temperature could not be explained unless his specific heat were less than 10,000 times that of water. Hence his specific heat is probably more than ten times and less than 10,000 times that of water. Therefore his temperature sinks 100° C. in from 700 to 700,000 years.*

The sun's density towards his centre must increase, because as the temperature becomes lower the whole mass contracts, and therefore by the initial coalition of meteoric bodies a greater heat must have been generated. The lowest estimate of the sun's initial heat would give ten million times a year's supply at the present rate, but fifty or one hundred millions as possible in consequence of the sun's greater density centrally. It is improbable that mechanical energy can increase in a body contracting in virtue of cooling.

Hence the sun must have been very sensibly warmer one million years ago than now. And if as a luminary he has existed ten or twenty millions

* Thomson and Tait's "Natural Philosophy."

of years, he must have radiated away more than corresponding numbers of times the present yearly amount of loss, *i.e.* 6×10^{30}, or six million, million, million, million, million, million times the heat to raise one pound of water 1° C. The conclusion, then, is that it is probable that the sun has not illumined the earth one hundred million of years, and almost certain that he has not done so for five hundred million years. For the future the inhabitants of the earth cannot enjoy light and heat essential to life for many million years longer.*

Lost Heat.

Ether may be compared to an "impalpable and all-pervading jelly, through which light and heat waves are continually throbbing, which is constantly being set in local strains and released from them, and being whirled in local vortices, thus producing the various phenomena of electricity and magnetism; and through which the particles of ordinary matter move freely, encountering but little retardation, if any, for its elasticity, as it closes up behind each moving particle, is approximately perfect. Nothing of the nature of an air-pump can remove it from any given space; the most perfect vacuum conceivable must be defined as a plenum and space fully occupied, but occupied by ether alone." †

* Thomson and Tait. † Daniell's "Physics."

"Ether can be set in vibration by the vibration of the molecules of ordinary matter." A local disturbance is produced which sets up waves, and "by these waves energy may be transferred from one place to another. This process of transference of energy is the process of radiation."

"Heat waves and light waves in ether are not waves of compression and rarefaction, like those of sound in air. . . . The vibration of the ether is initially of the nature of a forced vibration; it is probably excited by the oscillation of a part of the ether, which is in some way entangled within, or which envelopes the vibrating molecule." *

What becomes of solar heat radiated from the sun and stars?

There is no evidence of any heat reaching the earth from space besides that from the sun, except from the stars. Heat received from these when condensed in the focus of a telescope has been rendered sensible by the thermo-multiplier. Absolute zero is 493° F. below the melting point of ice. This is 222° below that of stellar space, which is not above – 239° F. Hence if the heat of the stars is able to maintain 222° of absolute temperature, *i.e.* – 239° F., then there is as much heat from the stars as there is from the sun; if this were the case, the stars should give out more light. But the temperature

* Daniell's "Physics."

of space is probably not much above absolute zero.

What becomes, then, of the heat radiated into space? From Newcomb's "Astronomy" we learn that—

1. It may be absolutely annihilated. 2. It may continue its onward course for ever. 3. It may be gathered and returned to the sources whence it emanated. The first is not philosophical because heat being an energy of motion cannot be produced except by the expenditure of force, actual or potential, in some of its forms; and force can no more be produced from nothing than matter can and its indestructibility is universally received as a scientific principle.

Secondly, that heat may continue its onward course for ever. As we receive heat from distant stars visible by telescope, which has been travelling thousands of years without any loss whatever, there seems no reason to exclude the radiation from the sun and earth from still pursuing its course through the stellar spaces without any diminution. A modern writer says: "If an intelligent being had an eye so keen that he could see the smallest object by the faintest light, and a movement so rapid that he could pass from one bound of the stellar system to the other in a few years, then, by viewing the earth less than the distance of the farthest star, he would see it by light which had left it thousands of years before. By watching he would see the whole drama of human history acted over again, except when actions were hidden by obstacles to radiation of light." The light from every human action performed under a clear sky is still pursuing its course among the stars and only with the above powers it could be seen again. Heat, then, is for ever lost and all expended in producing vibrations in the ethereal medium which constantly extends out further and further into space.

Thirdly, that it may be gathered and returned to its sources is simply conjecture, and, like the first, permissible by the imperfection of our knowledge.

"All the laws of radiation and all our conceptions of space lead to the conclusion that the radiant heat of the sun can never be returned to it. Such a return can result only from space itself having such a curvature, that what seems to us a straight line shall return to itself, as imagined by Riemann; or from the ethereal medium, the vibrations in which constitute heat, being limited in extent; or, finally, through some agency as yet totally unknown to science. The first idea is too purely speculative to admit of discussion, while the other two suppositions transcend our science as completely as does that of an actual annihilation of force." *

* Newcomb's "Astronomy."

CHAPTER III.

THE EARTH.

SOME of the materials which are found in the crust of the earth have by spectroscopy been shown to exist in the luminous atmosphere surrounding the sun. It is, therefore, assumed that the primary state of all the planets and their moons once resembled the present condition of the sun. Some of them, like our earth, have seas and atmospheres. On Venus, Mars, Jupiter and Saturn there are evidences of an atmosphere. Mars and Jupiter show changing shapes of clouds as though land and water were grouped in large mass and quantity; and Mars is believed to have ice and snow-capped poles.

In our moon the atmosphere of gases is presumed to have been small and to have entirely combined with the burning elements, for there is an absence of clouds and when about to pass over or occult a star, the star does not linger on the edge, as it would do, were there an atmosphere, but disappears at once. Hence the moon has no atmosphere, can contain no life but is merely a reflector of the sun's rays.

The earth is 1,245,126 times less than the sun, and, like a small as compared to a large red-hot ball, has ceased to give out light, having radiated its light into space as the sun is still doing.

The materials of which the crust and atmosphere are composed are sixty-four in number. But those which constitute the great mass of the crust are comparatively few.*

When a metal or non-metallic substance is burned it enters into combination with other gases present to become an earthy or mineral substance. Oxygen combines with many of these elements; indeed, one-half of the ponderable matter of the globe is composed of oxygen in a state of combination to form salts, some of which are soluble and found either in the ocean or deposited in masses from it; others are insoluble and, piled layer upon layer, constitute either sedimentary or igneous rocks.

Mr. Lockyer, quoting David Forbes,† describes the early condition of this globe as having been a glowing crust of acid silicates, surrounded by a dense vapour of the materials of the crust volatile at a high temperature. The vapour of chloride of sodium, or common salt, would be in large quantity; above

* Viz. aluminium, calcium, carbon, chlorine, sulphur, magnesium, potassium, barium, silicon, sodium, manganese, iron, fluorine, phosphorus, oxygen, and hydrogen.

† See Lockyer's "Lessons in Astronomy," and *Geological Magazine*, vol. iv. 1867.

this, a zone of carbonic acid gas; then a zone of aqueous vapour; and, lastly, oxygen and nitrogen to form our present atmosphere. The hydrogen burning oxygen formed steam vapour, which, when condensed into water, dissolved the sodium salt. As the cooling went on the lowest zones would be first condensed into a crust, then the aqueous vapour into water, dissolving the chloride of sodium to form salt seas; and lastly the carbonic acid, oxygen, and nitrogen to form the atmosphere.

As the heat became less the earth would shrink, grow cold, and cease to be an illuminating body. But under the fostering influence of the still burning sun, she has become clothed with plants and inhabited by animals and man. When the sun gave out more heat than he now does, the extremes of heat would be greater, storms and floods more violent, vegetation more luxuriant, plants and animals larger and coarser-grained. As the sun's heat declines, plants and animals will become dwarfed, till at last life will cease and the earth become a desert, for at present there appears no star to take his place.

Consolidation.

As to the time when consolidation took place from the molten state, Sir W. Thomson is of opinion that it happened much more recently than one hundred million years ago. Since then, shrinking and consolidation have progressed, so that probably the earth's centre is not now fluid. The earth, indeed, is extremely rigid, as if formed of solid steel. If this were not the case the earth would be drawn out of shape by the attracting forces external to it, just as the sun and moon draw the ocean towards them in tidal movement, or else tides would not exist.

The difference between the polar and equatorial diameter of the earth is $\frac{1}{300}$ of the earth's diameter; the deviation, therefore, of the earth's surface from a circle towards an ellipse is about 1 in 300. Ten million of years ago the centrifugal rotatory force of the earth was in the proportion of 67 as against 51 at present; that is, the earth rotated faster by $\frac{1}{7}$ than it does now. And if the earth completed consolidation at that time, the ellipticity of its upper layers would have a curve of 1 in 230 instead of a curve of 1 in 300, which it now has.

The continents of the earth are arranged along the meridians rather than in an equatorial belt, and prove that consolidation of the earth took place when diurnal rotation differed little from its present value, therefore more recent than one hundred million years ago.

The earth rotates on its axis in consequence of the angular momentum at its original separation. The influence of the tides in retarding rotation tends to show a slow diminution of the angular velocity, so that in time the length of the day and night will slowly increase until finally the duration of the day and that of the year will be equal. The earth will then have reached the condition into which the moon has passed relatively to the earth, one half being in continual day, the other in perpetual night. And, as a further consequence of the diminution of centrifugal force, owing to the retardation of the earth's rotation caused by the tidal wave, the sea level must have a tendency to subside at the equator and rise at the poles.*

This retardation of the earth's rotation by tidal friction may explain why the moon at the end of a century is $5''\cdot 7$ of arc in advance of her natural place relatively to a meridian of the earth. Allowing for retardation of the moon's mean motion by tidal reaction, Mr. Adams, in 1866, estimated that the earth's retardation, due to solar and lunar tides, is as the squares of the respective tide-generating forces, and to be twenty-two seconds in a century for the earth to be behind a perfect clock.† So that

* Geikie's "Geology."

† Besides retardation of the earth's rotation by tidal friction, the fall of meteoric dust must also be taken into account. But both these causes are to a minute extent counteracted by the contraction of the earth in cooling and barometric oscillations due to solar radiation; as the earth and sun constitute a thermodynamic engine by which the earth gains 2·7 seconds in a century.—Thomson and Tait, "Natural Philosophy."

at present, and for several thousands of years in future, the variation in the moon's motion is and will be an acceleration of twenty-two seconds per century in longitude.

Leibnitz supposes the earth to have been an incandescent liquid. If the temperature of melting rock is supposed to be about 10,000° F. the consolidation may have begun 200,000,000 years ago; but if melting rock be only 7000° F., consolidation may have taken place 98,000,000 years ago.*

Temperature of the Earth.

The internal temperature of the earth increases at the rate of one degree for every fifty feet of descent. At 2500 feet the temperature is 90° F.; at 3000 feet, 98° F. At this depth continuous labour is not practicable in moist air. The copper mines in Cornwall have a temperature of 114° F., 117° F., and 120° F.; the men only work for fifteen minutes at a time, or about three hours daily.

That temperature increases with depth implies loss of heat from the interior by conduction through the upper crust. And since this crust does not become hotter from year to year, there is secular loss of heat from the whole earth. Consolidation cannot have taken place less than twenty million

* Thomson and Tait.

years ago, or there would be more underground heat; nor yet four hundred million years ago, or there would not be so much as the least observed underground temperature.

The rate of cooling would diminish according to the inverse proportion of the square roots of the times from the initial epoch. The rates of increase of temperature inwards in a mass of rock at various times after cooling began, from 7000° F., would be—

For 10,000 years	...	...	2° F. per foot.	
„ 40,000 years	...	...	1° F.	„
„ 160,000 years	...	...	$\frac{1}{2}$° F.	„
„ 4,000,000 years	...	...	$\frac{1}{10}$° F.	„
„ 100,000,000 years	...	...	$\frac{1}{50}$° F.	„

As this is about the present observed rate, it is probable that for the last ninety-six million years the rate of increase of underground temperature has gradually diminished from about $\frac{1}{10}$° F. to $\frac{1}{50}$° F. of a foot. Hence volcanic energy, earthquakes, and the like were more abundant in antiquity than now.*

Consolidation, therefore, is assumed to have begun one hundred million years ago with the condensation and crystallization into the solid state of heavy metallic vapours, the last of which was that of chloride of sodium, or common salt. As the cooling progressed, steam, in its turn condensed into water, dissolved the upper incrustation of salt, ran into

* Thomson and Tait.

hollows to form seas. Though the earth was cold enough to allow of water being formed, yet it cannot be supposed that this water was cold; on the contrary, it was boiling hot, emitting vast volumes of watery vapour, which, with carbonic acid gas, oxygen and nitrogen gases enveloped the globe with a dense mephitic atmosphere. With cooling, consolidation progressed and was completed within ten million years ago, because the earth's curve is 1 in 300; but if consolidated at that time the curve would then have been 1 in 230.

The growth of the infant world may, therefore, be dated as beginning ninety-six millions of years back, and, like an immature mammalian embryo, drew its nourishment from the surrounding envelope of watery vapour and carbon to clothe itself with luxuriant vegetation.*

The earth's history is thus comprised between the time at which its surface had become cold enough to allow condensed steam to collect as water in seas,

* Professor Bischoff, says Dr. Hartwig, found that a single gas spring near Burgbroke daily produced 5650 cubic feet of carbonic acid gas, a quantity in the course of a year amounting to no less than 262,000 pounds in weight. The artesian well at Nauheim evolves every minute 71 cubic feet of carbonic acid gas equal to five million pounds annually. Hence the geological importance of such springs, which exert so great an influence upon the organic world. For carbonic acid in the atmosphere is absorbed by millions of plants; it feeds forests and fields. Chemical changes, therefore, incessantly and imperceptibly modify the earth's crust.

and that at which it will be so cold that all the water on the surface and all the vapour of water in the atmosphere will be turned into ice.

The Density of the Earth.

The density of the earth increases towards its centre, for as the spheroid cools by radiation, contraction of the whole mass follows. The crust, therefore, has been pressed into accommodation with the interior, inequalities of surface have been occasioned, and from the beginning a continual system of reciprocal depression and elevation has been established. Hence the spheroid would be wrinkled by folds of elevation and depression growing more and more deep—in time more complicated.

A contraction of $\frac{1}{100}$ of the earth's circumference would be sufficient to fold all the rocks in the mountain masses crossed by a meridian traversing the Alps. Professor Heine, of Zurich, has calculated that the extremes of the Alpine chain have by folding approximated seventy-four miles. If an indiarubber band be stretched out, and layers of different coloured clays superimposed—made to adhere as firmly as possible,—then by allowing the band to contract a series of contortions, inversions and dislocations will be produced in the overlying strata of clay, thus exemplifying the effect of the earth's contraction, showing that mountains are the effects of compression.*

If the surface of one side of a globe be crumpled into ridges east and west, no corresponding ridges occur on the opposite side, because the material of the crust is used up in that direction, but the predominant contraction will be on the opposite side at right angles running north and south. The Andes, Rocky Mountains, Alleghanies, and Cordilleras of Brazil, run north and south; also the Southern African, Madagascar and Australasian mountains all run north and south; while the east and west direction of the great Antilles depends upon the Andes. The Suliman mountains and Ghats alike depend upon the Himalayas. Ocean basins follow the same laws.

Crust of the Earth.

The crust of the earth may be likened to the peel on the outside of an orange. It is twenty-eight miles thick, composed of rocks of different ages and kinds, but belonging to two great classes:

I. Rocks deposited by water, called stratified or sedimentary.

II. Rocks that once were molten, called igneous rocks.

* Geikie's "Geology."

The sedimentary rocks have not always existed, and are piled one over the other in successive layers, the newer upon the older ones. They are the products of the wear and tear of other kinds. When water was first formed it dissolved and carried down common salt. Doubtless by this mechanical agency particles of the cooled lava were also worn away, carried down and sank to the bottom of the water-filled hollows. In this way, probably, began the first aqueous deposits. These deposits, in time, were transformed in structure and appearance by pressure and subterranean heat, or the heat to which pressure gives rise when arrested, into more or less crystalline rocks, termed metamorphic, plutonic or volcanic. In their turn these would be again decomposed, through the action of air and water, to be carried down and sink once more to the bottom. Probably there is no part of the earth's crust which has not been many times above and below the sea. This repeated change explains the variety and composition of rocks. The kaleidoscope may illustrate the idea of the wear and tear of rock-particles and their rearrangement on each revolution.

The igneous rocks were metamorphosed from sedimentary deposits. In consequence of the accumulation of sediments the temperature of the strata would be raised, and the heat thus developed would produce a crystalline condition. Under this influence of pressure the sediments would become heated to melting point (7000° F.), and the included water and other gases being given off with explosive violence, would produce earthquakes and volcanic eruptions. In volcanic regions steam or gas power is of enormous volume and magnitude. Steam pressure to raise felspathic lava five miles high is equal to about two thousand atmospheres. Probably the western coast of South America in 1822 was raised for a distance of a thousand miles, in places three or four feet, less by steam pressure than by the crumpling of the earth's crust; and mountain ranges have been lifted to their present height by lateral contraction breaking through and rising beneath strata superimposed by denudation. Internal movements happened at intervals during the whole period occupied in the deposition of the strata.*

Compression of rocks is at right angles to the cleavage of their planes. Lateral pressure operates on all strata, and the heat developed by pressure acts particularly on the argillaceous parts.

Sedimentary Rocks and their Thickness.

The whole of the sedimentary rocks are divided into five main groups, or periods; each of these again

* Phillip's "Geology."

into smaller groups and formations. The five main divisions are—

Primordial, in which are skull-less animals and forests of tangles.

Primary, in which fish and fern forests abound.

Secondary, contain reptiles and pine forests.

Tertiary, contain mammals and leaf forests.

Quaternary, man and his civilization.

The thickness of the stratified rocks may be estimated at 100,000 feet, that is nearly nineteen miles. Professor Haeckel considers them to be 130,000 feet thick; but this appears to be too high, for it assumes that the rocks occurred in one pile, which they do not and are nowhere complete. In the British Isles they are more complete than in any other area, and to the top of the Silurian strata the thickness is 60,000 feet. For the next main group the thickness is 25,000 feet, and for the Secondary and Tertiary periods 15,000 feet. On the continent of Europe the two last are 20,000 feet thick.

The oldest strata is the Laurentian and contains the first appearance of life—the eozoon Canadense, a compound species of foraminifera. The masses are several feet in diameter, and in the aggregate constitute accumulations of limestone. These rocks came to the surface through long continued elevation or denudation. The largest areas now exposed are in the northern parts of Europe and North America, elsewhere in isolated patches. They consist of gneiss, schistoze, and other minerals. In Scotland they are 20,000 feet thick, and in Canada cover 20,000 square miles.

The Cambrian and Silurian, next in point of age, are the only universal formations which extend throughout the globe. They are found as the floor of the sea and the materials of all emerged land when life first appeared. Their thickness has been acquired during a long era—from the time of the first formed crust—and may be as great as the time that has since intervened.

Professor Haeckel estimates the relative duration of the five main divisions, or eras, thus—

Primordial: Archilithic, Archizoic	53·6
Primary: Palæolithic, Palæozoic	32·1
Secondary: Mesolithic, Mesozoic	11·5
Tertiary: Cænolithic, Cænozoic	2.3
Quaternary: Anthropolithic, Anthropozoic ...	0·5

The entire stratified rocks of the globe are formed of old sea bottoms, except coral-beds and underclays; and beneath the oldest organic stratified rocks there are still older crystalline schists and metamorphosed strata. These rocks have been formed at all possible rates; nothing can be inferred from the thickness of a deposit as to the length of time required in its formation, so that great uncertainty prevails of all measurements for this end.

Rocks are disintegrated by chemical agency, rain, wind, land-ice and frost; on the other hand, rocks and the surface of the earth are protected from atmospheric action by clay or other covering, such as an ice-mantle. But the formation of strata depends upon the rainfall and velocity with which solid particles are carried down to a lower level.

Mr. Croll thinks that the rate of formation might be put at $\frac{1}{1200}$ of an inch per annum. Assuming that 72,000 feet is the mean thickness of all the sedimentary rocks, this would give an age of 1,036,800,000 years. And since from physical considerations the duration of life cannot be placed further back than one hundred million of years, "either the thickness of the rocks has been over estimated, or the rate of formation under estimated, or both."

Carrying Power of Rivers.

The denudation of the earth's surface depends upon the carrying powers of the river systems, and is the true measure of denudation. Humboldt estimated the average height of the American continent to be 748 feet, and that at the present rate of denudation the whole area of drainage will be brought down to sea-level in less than four and a half million years. Accepting the same author's average height of the Asiatic continent to be 1132 feet, the area of drainage by the Ganges would be brought down to sea-level in 930,000 years. And if the average height of Europe be taken at 671 feet, at the present rate of material carried down by the Po, it would be levelled in rather less than half a million years.

The following rivers carry down sediment sufficient to wash off one foot of rock from the general surface of their basins, viz.—

The Danube	...	in 6846 years.
The Mississippi	...	„ 6000 „
The Nith	...	„ 4723 „
The Ganges	...	„ 2358 „
The Rhine	...	„ 1528 „
The Thames	...	„ 1320 „
The Hoang Ho'	...	„ 1464 „
The Po	...	„ 729 „

The average time of these eight representative rivers is one foot of rock in 3121 years. But Mr. Croll does not consider that this mean is a safe guide, even supposing the above estimates to be correct; he prefers to accept the rate of denudation of the earth's surface as represented by the carrying powers of the Mississippi, because the rate of its denudation has been more accurately determined than that of any of the others, and fulfils all necessary conditions. Also, "that the average rate of denudation since the beginning of Palæozoic times was probably not much greater than at the present day," * viz. one foot of

* Croll's "Stellar Evolution" and "Climate and Time;" and Geikie's "Geology," where these subjects are fully discussed.

rock in 6000 years. With this calculation for the present we must be content.

Of the five main divisions into which stratified rocks are divided, the Tertiary formation possesses the greatest interest, for at the close of the Chalk period this formation underwent denudation, and the floor of the sea became elevated; the previous forms of life died out, none lived through the vast period in which these changes took place.

The Tertiary period chronicles the distribution of land and sea as we now see them, the beginning of most of the mountain chains, and a more highly developed flora and fauna. It is portioned into Eocene, Miocene, and Pliocene eras.

The table constructed by Mr. Croll exhibiting the eccentricity of the earth's orbit—for three million years, going far back into Tertiary ages—is instructive as marking periods of high eccentricity, which it is presumed corresponded to Three Glacial periods of great intensity of cold, besides other shorter and less severe times in succession to inter-Glacial or warm periods. As a general rule, those formations regarded as indicating a cold climatic condition are remarkably devoid of fossil remains. Although minor glacial periods doubtless existed with warm intervals, yet they have left but few traces of their existence. There are, however, traces of such times to be found in each hemisphere in the Cambrian, Silurian, Old Red Sandstone, Carboniferous, Permian, Oolite, and Cretaceous systems, besides the Tertiary period.

The First period extended between 2,600,000 and 2,460,000 years ago, embracing a period of 160,000 years. This period Mr. Croll assigns to Eocene times. In this formation is found "conglomerate devoid of all organic remains, and containing numerous enormous ice-transported blocks immediately associated with nummulitic strata charged with fossils characteristic of a warm climate"—a proof that a warm period succeeded a cold one. The Second period of high eccentricity extended from 980,000 to 720,000 years ago. This Mr. Croll assigns to the Miocene age. The Third period began about 240,000 years ago, and terminated 80,000 years since. This is considered the beginning of the Quaternary period.

Assuming this last date as a basis for calculation, denudation at the rate of one foot in 6000 years will have lowered the surface 13 feet in the last 80,000 years; and had the amount of denudation been greater, "drift deposits would not only have been less complete, but the general appearance and outline of the surface of all glaciated countries would have been very different from what they really are;" because, if the last period of glaciation be placed further back, at 720,000 years, denudation at the same rate would have removed 120 feet of rock from off the face of the country; and "if so much had been carried down, hardly a patch of boulder clay or any trace of that Glacial epoch would now remain."

Sir Charles Lyell considers that when we go back to the lower Miocene formations marine shells differed as a whole from those now existing. "But only 5 per cent. of the shells existing at the commencement of the Glacial epoch have since died out. Hence, assuming the rate at which the species change to be uniform, it follows that the lower Miocene period must be twenty times as remote as the commencement of the Glacial epoch." Consequently, taking the Glacial epoch to commence, as above calculated, 250,000 years ago, and change of species at 5 per cent., about fifteen millions of years will have passed since the beginning of the Eocene period; forty millions of years since the commencement of the Carboniferous period; and sixty millions of years in all since the beginning of the Cambrian period; and probably the pre-Cambrian age may be as great as that which has elapsed since the close of that period.

Denudation, or the washing away of the earth's surface, is, therefore, a momentous process in continual progress throughout the world, except when either hemisphere is under glaciation, for then the process is arrested in that locality. Hence denudation can only be calculated at the rate laid down when conditions exist as at present.

Every day about 1000 tons of carbonate of lime and 230 tons of sulphate of lime are carried down by the Thames into the sea, besides other salts of magnesia, potash, soda, silica, iron, alum, and phosphates. In all, 1500 tons of solid matter is daily carried to the sea by this river alone. This amount represents surface denudation equal to less than $\frac{1}{10}$ of an inch in 100 years, or one foot in 1320 years from the chalk and oolite districts.

Caves, Earthquakes, and Volcanic Action.

Caves, such as are met with in Yorkshire, Derbyshire, Devonshire, and elsewhere, are excavated by the action of water condensed into a narrow stream. This water is impregnated with carbonic acid absorbed from the air added to that from decaying vegetation. In a limestone country mountain surface water often disappears in fissures to reappear at an opening some distance off. A fissure, therefore, through the mechanical and solvent property of water aided by friction, becomes enlarged; caverns are gradually hollowed out; but as this process requires time it occupies many thousands of years.

The Niagara gorge is seven miles in length. At the rate of one yard in one year, 12,000 years would be required for its formation. The rock at Niagara is limestone, 90 feet thick, overlying 80 feet of shale. The cutting back of the bed of the river is due to removal of the underlying shale undermining the limestone, which then falls in.

The inundation of the Nile raises the land of Egypt 4½ inches in a century.

Besides denudation of the earth's surface by water, it is altered by volcanic agency. Existing volcanoes run in chains; or, rather, lines exist in regions of conspicuous upheaval still undergoing elevation; they are supposed to be the results of terrestrial contraction. Deep beneath many volcanoes stratified rocks exist; hence plutonic rocks have, most probably, been metamorphosed out of such stratified materials.

Earthquakes are more numerous in mountain regions than in plains; are more numerous in winter than in summer, as if the radiation of the earth's solar heat caused contraction of the rocks, which then produces perceptible vibration through the dislocation which occurs. In Switzerland earthquakes happen mostly at night. As a rule they do not extend to any great depth into the solid crust of the earth; but in great earthquakes they vary from one mile to thirty miles in depth. They would appear to be connected with internal movements consequent upon contraction of the earth's crust from cooling.

Mr. Mallet is of opinion that the existence of reservoirs of fused matters at various depths in the solid earth rind is sufficient to account for all seismic and volcanic phenomena. Whenever water percolates through rocks and gains access to these molten masses, steam must be generated, the pressure of which will rend and dislocate superincumbent masses.*

It is probable, as Mr. Darwin points out, that there is not a minute of time without its earthquake somewhere. Earthquakes are preceded by slight tremors, and within the last fifteen years it has been discovered that the earth's surface is being continually shaken by tremors so minute as to remain unsuspected without the intervention of the most delicate instruments. In every locality where the experiment has been tried these tremors have been detected, and not merely at certain periods, but so incessantly that there is never a second of perfect rest. The earth may fairly be said to "tremble like a jelly." Father Bertelli in Italy is the pioneer in this investigation, but it is found to be true equally for England, France, Egypt, Japan, Brazil, and a South Sea island; so that these microseisms are not confined to any country especially visited by earthquakes.†

Volcanoes are distributed in lines of anticlinal folding. Earthquakes may be produced by compression of the region of synclinal folding. The

* Mallet on "Earthquakes."

† *Fortnightly Review*, February, 1887.

base of a synclinal fold becomes fractured, and a fissure is formed at the depth of some miles. Volcanoes are thus left for mountain tracts, while earthquakes at sea are intelligible.*

Thus we see that water exercises an immeasurable influence over the construction and destruction of the globe. It dissolves and suspends various portions of mineral ground, washes away small particles from off the plains and mountain slopes of the land, excavates and deepens caves and valleys, whilst as breakers of the sea it attacks the cliffs with gigantic power, and by its enormous suction-force carries away all loose materials to fill the valleys of the sea.† So that in a few millions of years, by subaërial denudation and the transporting power of the sea, the earth's surface might become one sheet of water, were it not, on the other hand, that the ceaseless trembling from earthquakes, the constant volcanic eruption of molten fluid, and contraction from secular loss of heat, create alterations in sea-level both with depression and elevation throughout the globe. These phenomena have taken place slowly and imperceptibly for millions of years, so that first one portion, then another of the solid crust of the earth is above or below the sea. To these causes, therefore, we owe our varied and varying scenery.

* Phillip's "Geology."

† Vide "Climate and Time," chaps. xx., xxii.

CHAPTER IV.

THE FIVE GEOLOGICAL PERIODS.

THE sedimentary rocks are classed under five main groups, or periods, and each of these again into smaller groups or formations.

The Primordial, Archilithic, or Archizoic era ranges from the first appearance of life. It is an immeasurable period of time, longer than the remaining four together. The strata in this period are supposed to be 60,000 feet in thickness, or 53·6 per cent. of the whole. Many millions of years were required to deposit such masses of strata. Few petrifactions have been preserved because the forms were only water inhabitants, and their bodies soft and perishable. They belonged to the lowest groups of plants and fishes. Tangles were the chief representatives of plants; and some idea may be formed of the extent of forests of tangles which existed in the warm primæval sea, by their descendants in the tangle forests of the Atlantic Sargasso Sea—an area equal to the Mississippi valley—midway between the Canary and Cape de Verd Islands. Fishes are very poorly represented; the few remains known are found in the upper Silurian strata; but headless vertebrates are presumed to have lived in vast multitudes during this era.

The second, Primary, Palæolithic, or Palæozoic division is also one of long duration, represented by 25,000 feet of strata—31·1 per cent. of the whole geological period. The Devonian and Permian formations are rich in the class of fishes called ganoids, but deficient in the bony variety (teleostei). The most ancient remains of animals living on land are found in the coal formation; spiders and insects among the articulated class; frogs and newts among amphibious vertebrates. The amphibia of the Permian period were more highly developed than those found in the earlier coal formation.

This era may be called that of fishes, because, in comparison with their vast numbers, amphibia were few; more especially perhaps that of ferns, which predominated over fishes. The ferns which grew on land formed the chief part of dense island forests now known as coal. Wherever vegetation has accumulated in swampy districts, necessary for its preservation, coal has been formed, and hence it is of every geological age. When vegetation is exposed to the air, which is not excluded by water or a covering of clay, humus and not coal is formed.

The formation and conversion of vegetable matter into pure carbon imply a vast period of time, with many changes of land and water. Some of these strata are laid down in deep water, others in shallow fresh water or marine. The coal measures consist of alternating strata of sandstone, shale, and coal, with courses of nodular clay, ironstone, and layers of bivalve shells.

In England the carboniferous system extends 200 miles by 60 miles in breadth—from Northumberland to Nottinghamshire, and from South Wales and Gloucestershire to the Mendips. Scar limestone is known by the herbage, it is short, elastic, nutritious and of a bright green colour; for in Britain alone, and in no other region of the world, is this limestone so extensive or varied.

The entire coal acreage in England is 2,500,000 square acres. The smallest field contains 60,000, and the largest 600,000 square acres. In Scotland there are 1,000,000 square acres, or 6000 square miles of coal measures. The Welsh coal-fields are 10,000 feet thick, and the Bristol coal measures 6000 feet. At Mons, in Belgium, the coal basin is 5330 feet in thickness; at Liege nearly 4000 feet; at Saarbrücken, in Prussia, it is 21,000 feet thick in a square area of 900 miles. In America there is twenty times the amount in England and Europe, equal to 200,000 square miles. In South Wales there are coal-fields 6000 or 8000 feet below the

Bristol Channel, the out-crop edges of which will never be touched in our time. Every bed of true coal represents an ancient land surface. Strata with coal-beds are a measure of the actual sinking of the surface for this period. In the South Wales coal-fields the combined thickness of coal throughout 12,000 feet of sedimentary materials amounts to forty yards. Assuming that one yard of coal would require one thousand years for its formation, and strata were deposited at the rate of two feet in a century, corresponding to the rate of subsidence; then, $\frac{12000 \times 100}{2} + 40,000 = 640,000$ years—the period required to produce this coalfield.*

Anthracite, or smokeless coal, used for steamers, in South Wales lies over igneous rocks, which, through their high internal temperature, probably 467° F., may have caused changes in its nature forming anthracite; and this high temperature may have arisen from pressure due to strata of 10,000 or 12,000 feet in thickness, since removed by denudation. Temperature, therefore, above that of boiling water liberated gases which converted the bituminous matter into pure carbon—anthracite or stone coal. But the two causes—pressure and internal heat—may have been combined to produce this effect. Pennsylvania, Massachusets, and other places abound in this kind.

* C. Maclaren's "Geology of Fife," p. 153, *et seq.*; Hull on "Coal-fields," p. 71.

In America there are 163,000 square miles, or thirty-three times the quantity in Great Britain, untouched. The British coal-fields contain enough for the next two thousand years' consumption.

"A large portion of the centre and south-west of Ireland is occupied by carboniferous limestone, upon which at intervals repose higher strata productive of coal, and forming isolated coal-fields. The existence of these outliers, as well as analogy with British geology, leads to the conclusion that at the close of the carboniferous period large tracts of coal-bearing strata existed over Ireland which have since to a great extent been removed by denudation." * The Clyde basin is rich in cannel, or gas coal.

There are two kinds of coal: black or anthracite, and brown or lignite. Both kinds are due to the transformation of vegetable matters, by the elimination of oxygen and hydrogen, into a substance richer in carbon than the original wood. The nature of the change is a slow oxidation under water or under an argillaceous covering which protects dead wood from

* The earliest mention of coal is by Theophrastus, 238 B.C. The ancient Britons worked coal, as evidenced by the discovery of a flint axe in a coal bed in Monmouthshire, also of oak axes or picks near Stanley, in Derbyshire. The Romans in Britain used coal, attested by ashes in the camp at Mancunium (Manchester). The Saxons used col—now coal. In 1259, Henry III. granted a charter to the freemen of Newcastle-on-Tyne to dig for coal. Coal was not in general use till the time of Charles I. For other interesting information, see E. Hull on "Coal-fields," third edition.

atmospheric action; otherwise humus and not coal would be produced. In anthracite no plant structure is discoverable owing to a metamorphism analogous to that of the sedimentary into crystalline rocks.

The flora concerned in the production of coal differ with different geological periods. The Tertiary, Cretaceous and Jurassic differ from the Palæozoic era, and have no representative flora since that period terminated.

The flora were transformed on the site of growth upon a bed of clay below containing the roots of the plants. In Yorkshire, on sandy soil, the conditions favourable were forest in swampy ground and estuaries at river mouths, with oscillations in level, governing accumulation. Its formation was analogous to peat. Intercepted drainage killed the forest trees. Peat, like coal, alternates with clay. Acrogens—at present ferns, equisetaceæ and lycopodiaceæ—chiefly predominated, and owing to their power of endurance have been preserved; they were of gigantic proportions. The tree ferns of to-day are to be considered only as relations of those of a former age. The genus sigillaria and its roots stigmaria, seen in geological specimens, belong to the class lycopodiaceæ, and along with the equisetaceæ—known as calamites—are most abundant.

In conclusion, there are 48,000 million tons of coal at from 4000 to 6000 feet in depth, an amount hardly likely to be reached, on account of the great heat to be encountered and the increased cost. The time which elapsed between the beginning of the Coal system and the end of the Permiam must have been enormous. And it has been observed that in this latter period there was a great advance in the development of reptiles. But, as in the former period, the species are all extinct.*

The third, Secondary, Mesolithic or Mesozoic division is principally marine, consisting of repeated alternations of limestone, flint, sandstone, sand, clay, iron ore, coals, etc.; and organic remains are all extinct. This period is remarkable as the era of pine forests, which were later on replaced by leaf-bearing forests, developed then for the first time. Reptiles predominated in this period as fish in the former. There were swarms of remarkable flying lizards and colossal land dragons. The close of this period ushered in the first birds and mammals. The jaws of the birds carried teeth, and their vertebræ were biconcave.

The physical features of the Chalk period were that the land was not so elevated as in the immediately preceding Jurassic formation; but there were broad swelling hills; smooth, winding, and often dry valleys, with a bare grassy surface into which water readily sank, leaving the surface dry. Water was

* See Phillip's "Geology," and Hull on "Coal-fields."

thus stored up in deep wells, from which perennial springs issued at lower levels. In England chalk is found in Yorkshire, Lincolnshire, Norfolk, Suffolk, Buckinghamshire, Wiltshire, Dorsetshire, Hampshire, Surrey, Kent, and Sussex.

There is no evidence that chalk was deposited over a sea-bed like the Atlantic in depth. The microscopic fauna have little relation to globigerina ooze, except in the genus globigerina; and other remains are at variance with the view associating them with the condition which now exists in the floor of the Atlantic. Chalk is not deposited homogeneously, but has undergone oscillations by emersion and denudation.

The Cænolithic, Cænozoic or Tertiary era is the fourth of the main divisions. It is shorter than any of the preceding, having only a proportion of 2·3 to the whole geological period; but the most interesting, for the modern distribution of land, sea, and mountain chains are herein chronicled. The strata are partly limestone, but principally marine, sandy, and argillaceous, with some calcareous deposits abounding in shells and other organic exuviæ analogous to existing species.

The gigantic flora and fauna, called forth through the great specific heat of the earth as well as the greater heating power of the sun, slowly disappeared, giving place to an increase of developmental activity and adaptation of organs suitable to changed circumstances. The luxuriance of cell-growth was restrained—the carbonic acid gas had been used up —the atmosphere had become purer and plants and animals exhibited a corresponding increase in vigour. Plant-seeds were no longer naked, and animals proceeded to the highest type of mammals. This period is portioned into Eocene, Miocene, and Pliocene. Its duration was several million years, and ranges probably from three to fifteen millions of years since its commencement.

The Eocene period comprises marine sands, as at Chiselhurst, Thanet, and the strata between Bournemouth and Poole. The harbours are of fresh water origin, and the cliffs of yellow, white, orange, and black sands and clays, rich in nineteen species of ferns. A great river may have existed, and the Bournemouth cliffs represent a section across its bed.

In the Miocene period Britain is supposed to have formed part of the continent. The flora exhibit a tropical climate as prevailing in the earlier part of the period, for some of the most characteristic forms have their modern representatives in India and Australia. Miocene deposits are not known to occur in Britain, but in the Sewalik Hills in India there has been found a hippopotamus with six incisor teeth, whereas the living African type has only four. The Miocene flora comprise three thousand species, the greater portion being extinct. The invertebrates are numerous, and mostly of existing types. The elephant was not found at this period in Europe. The mollusca species found indicate a hotter climate than at present.

The Pliocene period is seen in the eastern part of England—from Walton in Essex to Aldborough in Suffolk, in Norfolk, and at Bridlington in Yorkshire. Its general aspect is a ferruginous mass of shells, dark pebbles, bones and teeth of fishes, in a confused sand mass like a modern shelly beach. It is also found along the Apennine Chain and in Sicily several thousand feet thick, deposited during the slow and continued depression of the Mediterranean. This is the only European area of any size of this formation.

The flora and fauna of this period indicate a land passage between Britain and the continent. In pre-Glacial periods Britain was relatively at a higher sea-level than now. Probably there was no German Ocean nor English Channel. The advent of a colder climate is also shown by the character of the fauna. There is no means of estimating the time between the close of the Miocene and deposition of the Pliocene beds, during which the Miocene strata were removed by denudation. In this period Britain locally subsided (after denudation) to a small extent. Pliocene life is illustrated by numerous molluscs; mammals; ungulates—tapir and rhinoceros, mastodon and elephant—equidæ—carnivora, as bears, tigers, and lions; quadrumana, as in semnopitheci and manaques.

The sub-Apennine strata of this period are 3000 feet thick, and comprise a vast period for accumulation in the Mediterranean Sea, from which they have been uplifted on each side of the secondary Apennine ridges. They consist of alternations of calcareous and argillaceous marl, light brown or grey. Since the accumulations of the newer Pliocene strata the whole cone of Etna, 11,000 feet high and 90 miles in circumference, has been slowly built up.

The Quaternary, Anthropolithic or Anthropozoic, is the last division, and embraces man and his culture—or that of cultivated gardens and forests—because at the lowest stage of human civilization man's influence is perceptible in the utilization of forests and their products.

The strata deposited in this period are of slight thickness, from 300 to 500 feet, and consist of two formations—the post Pliocene and the Recent.

The post Pliocene is found at Amiens; in the Nile and Rhine valleys; in Sardinia 300 feet in depth; at Liege, with human remains; in Australian drift, and Glacial drift of Northern Europe; North America; Thames and Ouse valleys; Scotland, Norfolk, and in Wales, with marine fossils 1400 feet above sea level; the average thickness being 300 feet. The species are mostly still living.

The Recent strata are marine strata enclosing the Temple of Serapis; at Puzzuoli; lacustrine strata; lacustrine mud with Swiss lake dwellings; Danish peat; and peat with human remains in the Clyde estuary.*

Man is supposed to have acquired speech in this period. It may comprise hundreds of thousands of years, but vanishes into nothing when compared with the beginning of life.

Preservation of Fossils.

"The geological record as a history of the world has been imperfectly kept and written in a changing dialect. As every animal and every plant from the beginning of its individual existence passes through a series of different forms, it indicates, in rapid succession and in general outlines, the long and slowly changing series of states which its progenitors have passed through from the most ancient times." †

In deep sea and beds of broad rivers deposits of mud would be small, but comparatively great on sea-shores, estuaries of large rivers and inland seas. At the mouth of the Mississippi in 100,000 years

* Vide Phillip's "Geology."
† Haeckel's "History of Creation."

at the present rate of discharge a deposit of 600 feet of mud would take place.

Ground rising with newly deposited layers of mud, enclosing remains of plants and animals, and subjected to the action of breakers would be worn away. Hence it is only in sinking ground that deposits could be preserved. On this account, therefore, petrifactions of intermediate forms formed in rising ground would be lost, whilst those in sinking ground would be preserved; for intermediate forms between old and newly formed species must have lived during periods of elevation as well as those of depression. The vertical sequence of rocks —limestone, clay and sand when met with—is regarded as evidence that during the whole of the geological time represented by these deposits the land was being upheaved.

Besides the loss of petrifactions through the periods of elevation, the palæontological record is further destroyed by the crystalline condition of the lowest stratified rocks, either through the internal heat of the earth or the effect of heat induced by pressure, so that organic remains have been completely destroyed. Yet in some instances, as the *oezoon canadense* * in the Laurentian rocks; in layers

* The eozoon canadense belonged to the rhizopods. Its massive skeletons, composed of innumerable cells, would seem to have extended themselves over submarine rocks; their base

of graphite (crystalline charcoal) and marble, petrified vegetable and animal remains have been preserved. Again, it may be noted that only the harder parts of animals and vegetables can be preserved—as bones, teeth, shells, and woody or silicious parts of trees and plants—while, naturally, the soft and delicate parts would be lost. Hence of naked molluscs, worms, and the lowest vertebrate animals, which possess neither firm nor hard parts, few petrifactions would exist.

Further, bodies of sea animals are more likely to be preserved in deposits of mud than those of land animals in sea mud. Hence the majority of petrifactions belong to inhabitants of the sea.

Of fossil mammals of the Secondary period nothing is known but the jaw-bone—a solid bone easily separated from a dead body floating about disintegrating in water—which would sink and become embedded in mud.

In the Jurassic system, near Oxford, only jawbones of numerous pouched animals have been found. These are the most ancient of all fossils, and nothing is known as to the remainder of their bodies; footprints also have been found of vertebrates, probably reptiles, of whose bodies there is no trace. In this system has also been discovered a fossil

upwards of twelve inches in width, and their thickness from four to six inches.

bird with a lizard's tail; this points to the reptile being the ancestor of the bird.

Intermediate forms have always died out quickly, and are but rarely preserved as fossils, yet the most divergent forms were able to maintain themselves longer in the struggle for existence.*

* Haeckel.

CHAPTER V.

CLIMATE.

Growth and distribution of flora and fauna upon the earth arise from physical agencies which in the course of ages imperceptibly but completely change the period of the seasons as we know them. Little heed is given to these agencies by the public in general, partly on account of the complexity of the subjects and partly from imperfect knowledge and defective methods of instruction; but as technical education grows in public favour the difficulties surrounding these subjects will disappear; and the investigations and knowledge of astronomers, geologists and physicists, when harmoniously combined, will enable any one with ordinary intelligence to understand and appreciate the changes which have occurred in this northern hemisphere, during the infancy and growth of the human race; to value the advantages which this race now enjoys in what may be considered its adult life; and to surmise what will again be the condition of this hemisphere when the race may arrive at old age and its existence be determined.

Those who never leave the shores of Britain cannot conceive the vast difference which increase or decrease of temperature combined with moisture will effect in the growth of plants and in the habits of animals, nor yet understand their distribution in the world. Such must be content to believe not only in travellers' stories, but in travellers' scientific facts; and had Mr. Stanley returned from his adventurous expedition a quarter of a century ago he would have met with the incredulity and mockery experienced by Du Chaillu. But times have changed, and though the ridicule cast upon Du Chaillu may redound to the triumph and honour of Stanley, yet the former is doubly avenged; for not only was his narrative true, but it remains uncontradicted, and describes feats of daring and personal adventures which certainly are not second to those of the later explorer.

Those who travel, whether for pleasure or gain, have impressed upon them more and more each time they do so the effects which the combination of temperature and moisture produce. Hot-houses give a feeble idea of such altered conditions upon plants, and visitors to them do not live for years under such conditions, so that these places afford but little practical knowledge of what lengthened sojourn in tropical, or in arctic, regions is like; hence visitors are incapable of rightly estimating what would be

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the effect of such conditions, and they must accept therefore the experience of others on such subjects.

Britain is situated within the parallels of 50° and 60° north latitude, the Falkland Isles within the same parallels of south latitude, yet what a difference of climate is manifested! Britain rejoices in its trees, cattle and wheat-growing conditions, because this hemisphere is in the perihelion of the earth's orbit, has a short winter and a long summer and is warmed by the Gulf Stream; whereas in the Falkland Islands the two first of these conditions are reversed, and the third has but little if any influence.

At see-saw, children are not conscious how in that game they are representing the equatorial protuberance of the earth at the solstices in her revolution round the sun, nor of the momentary equilibrium of that protuberance at the equinoxes, as they rest balanced. Those again who make a summer excursion to the North Cape of Europe do not think of the heat they will encounter. Accustomed as they are to this cool, foggy climate they are not prepared for the effect of exposure to the sun's rays for twenty-four hours. They cannot realize months of prolonged daylight nor of prolonged night, as neither condition exists anywhere else in the world except at the poles—even the fauna and flora at the equator have a rest of twelve hours' night all through the year. When they start they little expect to find that instead of an arctic temperature they will experience a more than tropical one, for the north pole though further from the sun than in winter is then turned towards the sun. From books and otherwise the fact is known, but the practical knowledge acquired, impresses this fact, enlarges the understanding and disposes them to be more ready to accept the theories and deductions of scientists on the growth and variation of species through alteration of climate, than those whose intellects have not been sharpened by travel. It will be necessary, therefore, to give a short account of some of these agencies—fully discussed by Mr. Croll in "Climate and Time" and by Mr. Wallace in "Island Life."

"There are two causes," says Mr. Croll, "affecting the position of the earth in relation to the sun, which must to a very large extent influence the earth's climate; viz. the precession of the equinoxes and the change in eccentricity of the earth's orbit."

The phenomena of precession of the equinoxes and nutation are due to the attraction of the sun and moon on the protuberant parts of the earth's surface at the equator, which by their unequal pull cause the earth's axis to shift its position—that is, there is a continual displacement of the plane of the terrestrial equator. In other words, these phenomena result from the fact that the earth is not centro-baric,* *i.e.*

* Thomson and Tait's "Natural Philosophy."

the reaction of the sun and moon do not pass through the earth's centre of inertia except in planes of the equator.

The ecliptic is the plane in which the earth revolves round the sun. Very nearly also in this plane the major planets—Mars, Jupiter, Saturn, Uranus and Neptune—perform their journeys round the sun; but the orbit of each of these planets is outside and far beyond that of the earth.

The earth rotates from west to east on her own axis, inclined at an angle of 23° 27′ 24″ to the plane of her orbit, at the rate of 1521 feet per second. And she revolves from west to east in an elliptical orbit at the rate of 96,500 feet per second.

In consequence of these two motions the reactions of the sun and moon pass through the centre of the earth's inertia only when the spheroidal excess about the equator is in the same straight line as the centres of the sun and earth.

The attraction-power of the sun acts upon the whole earth to keep her in her orbit but is more powerful on the protuberant parts. This protuberance is massed about the equator, and as rotation of the earth on its axis is constantly varying this portion in its revolution round the sun, each portion of the protuberance is brought under the sun's inflence; the molecules immediately acted upon are met by the counteracting efforts of those molecules contrarily disposed, and thus at every instant of time an average will be struck which will be in favour of a recess of the node save only when situated in the plane of the earth's equator.*

At the autumnal and vernal equinox, antagonism has momentarily ceased, but at the aphelion and perihelion points when the inclination of the equator to the ecliptic is at its greatest variation, the sun's influence is at maximum intensity on the protuberance around the equator.

A straight line drawn through the centres of the sun and earth to each side of the ecliptic will have the spheroidal excess at those points (perihelion and aphelion) on one side above and on the opposite side below the plane of the ecliptic; and the resultant action of attraction and rotation is to bring this spheroidal divergence into the plane of the ecliptic. "What happens with one particle in the protuberance happens with all; one half of it, therefore, tends to fall, the other half tends to rise, and the whole earth meets the strain by rolling on its axis. The inclination of the protuberance to the plane of the ecliptic is not altered, but, in consequence of the rolling motion, the places in which it crosses that plane precede those at which the equator would cross it were the earth a perfect sphere." †

* Herschel's "Outline of Astronomy."
† Lockyer's "Lessons in Astronomy."

Terrestrial longitude reckoned from Greenwich is the same year after year; but celestial longitude is measured from the vernal equinox. This point shifts backward from east to west, contrary to the motion of the earth in her orbit, to the extent of $50''\cdot1$ of arc per annum, an extremely minute quantity, but which by accumulation makes itself palpable in a way highly inconvenient to practical astronomers, says Sir John Herschel.* This slow negative rotation of the equinoxes requires the revolution of the pole of the celestial equator round the pole of the ecliptic, so that the earth describes a cone whose axis passes through the pole of the ecliptic.

If the sun alone acted upon the earth, precession would be an accurate ellipse round the pole of the ecliptic; but the moon whose precessional force is three times greater than that of the sun has, also, a special attraction-effect due to the revolution of her nodes in nineteen years which cause the ellipse in its journey round the pole of the ecliptic to assume a wavy or crenated outline. This is nutation.

But the ellipse of the earth's orbit rotates towards

* The seconds in a circle are 1,296,000 : if divided by $50''\cdot1 =$ 25,868. And the seconds in a year divided by 25,868 = 20 min. 19·9 secs., so that equal days and equal nights come every year so much earlier; hence 360° of longitude at this rate will require 25,868 years to complete a tour of the ecliptic. Mr. Newcombe says this time is 22 min. 20 sec.

the east—going forward at 11″·8 of arc per annum * —in a direction opposite that in which precession occurs. Rotation of the earth's axis round the pole of the ecliptic at this rate, would occupy 109,830 years or 1° in 305 years. Hence the vernal equinox and the perihelion point recede from one another by a joint annual amount of 61″·9. This is the same as if the perihelion point revolved once in 20,936 years or 1° in 58 years. This constitutes the anomalistic year, or passage of the earth from one perihelion or aphelion point round her orbit back again to the same point.

If a plane parallel to the earth's equator be drawn through the sun's centre, the earth's orbit will be cut in two points—vernal and autumnal equinoxes. The line joining these two points divides the earth's orbit into one larger than the other. The smaller one corresponds to our present northern hemisphere; this portion moves faster on account of its proximity to the sun, for velocity † is inversely as the distance

* The seconds in a circle divided by 11″·8 = 109,830 years and 109,830 divided by 360° = 305 years. The seconds in a circle divided by 61″·9 = 20,936 years and 20,936 divided by 360° = 58·158 years.

† Motion in an ellipse is a variable rate of progress at different parts of the curve, and proximity to the sun is compensated by the effect of swifter motion; but in a circle, says Lockyer, "the motion is always at right angles to the line joining the two bodies; this condition of things occurs only at two points in an ellipse, *i.e.* at the *apses* or extremities of the major axis—the aphelion and perihelion points."

from the sun's centre. Winter extends from September 22 to March 20 and occupies 179 days; summer from March 21 to September 21 or a period of 186 days. Therefore the northern hemisphere has a shorter winter than the southern hemisphere by seven or eight days.

The precession of the equinoxes then—occasioned by a continual daily displacement of the plane of the terrestrial equator at the ecliptic—causes in a long series of ages changes in the times of the seasons, and length of summer and winter days on opposite poles. In the year A.D. 6485, says Lockyer, the vernal equinox will occupy the position of our present mid-winter in perihelion. In 10,500 years more our midwinter will be in aphelion and midsummer in perihelion, *i.e.* England with reference to to the sun's position at that time will have changed places with New Zealand, or more correctly the Falkland Islands.

The second of the two causes which influence the earth's climate is the eccentricity of its orbit.

The earth's orbit is an ellipse round the sun. The sun is situated in one of the foci of the ellipse, and the earth when nearest the sun is said to be in perihelion as in our winter, and when furthest off as in midsummer in aphelion.

In the journey round the sun the earth does not always pursue the same elliptical path. The attractions of the planets daily alter the shape of the orbit so that the orbit or track at one time makes nearly a circle, at another an oval outline. This is eccentricity; it oscillates between a maximum and a minimum. At present the path is approaching the circular route, and in 24,000 years one of the minimum points will be reached.* Then after a long cycle of changes maximum eccentricity will be attained to recede once more as before. The intervals between consecutive turning points are unequal in length; some periods of high eccentricity last longer than others; and the orbit at some epochs of high eccentricity is more elliptical than at others.

"The total quantity of heat received from the sun during one revolution, is inversely proportional to the minor axis. The difference of the minor axis of the orbit when at its maximum and its minimum state of eccentricity is as 997 to 1000. This small difference cannot therefore sensibly affect the climate." † Hence change of climate does not depend so much upon the condition of eccentricity as from its combination with the precession of the equinoxes. For the direct heat of the sun is inversely as the square of the distance. So that the hemisphere furthest away and turned from the sun will receive a less amount of heat than the opposite

* Croll on "Climate and Time." † Ibid.

hemisphere, and the winter will be longer. This is due to the precession of the equinoxes in the course of ages.

At present England in winter is turned away from the sun, and Australia towards the sun. The winter in England is short and the summer in Australia is short in consequence of the nearness of the earth to the sun. But summer in England is eight days longer than the winter, and winter in Australia is eight days longer than its summer, in consequence of the increased distance of the earth from the sun. Hence the heat England loses in winter she gains in summer through its increased length, and Australia *vice versâ*. This is explained by recollecting that the increased velocity with which the earth moves in her orbit when nearest the sun is compensated by her slowness of motion when furthest from the sun.*

The *mean* distance of the earth *at present* from the sun is assumed to be 92,500,000 miles. The least distance in winter, perihelion, is 91,000,000 of miles; and the greatest in summer, aphelion, is 94,000,000 of miles.

In *maximum* eccentricity or ellipticity the earth in round numbers will be 85,200,000 miles distant from the sun in perihelion, and will be 99,600,000

* See diagram recently published by Messrs. George Philip and Son, of Fleet Street, where a miniature earth can be placed in any position relatively to the sun.

miles in aphelion distant, or a difference of 14,400,000 miles in the two positions instead of 3,000,000 miles at present.

If, through the precession of the equinoxes, our northern hemisphere is in aphelion when the earth at the same time is at its maximum state of eccentricity, the earth will be 8,600,000 miles further from the sun in winter than she is at present; the direct heat of the sun on this hemisphere will be one-fifth less in winter and one-fifth greater than in summer. Though the yearly amount of heat received would not be altered, yet owing to the increased distance from the sun the rain which *now* falls, or is converted into snow, would *then* be snow and would not disappear so rapidly as under present circumstances. The air would be colder because the snow-clad ground could not absorb heat and the winter temperature would be prolonged, for the snow at the beginning of the summer season would not all be melted. Ground covered with snow reflects but does not absorb the heat-rays of the sun. Owing to the coldness of the atmosphere every shower of rain would fall as snow and not only prolong the winter, but winter would commence earlier.*

* The temperature of space is $-239°$ F. Our midwinter temperature is 39° F. Thus $239°+39°=278°$ F., being the number of degrees rise due to the sun's heat at midwinter. Consequently 1000 sun's rays are required to maintain the temperature in Great Britain 278° above the temperature in space. Therefore as 1000

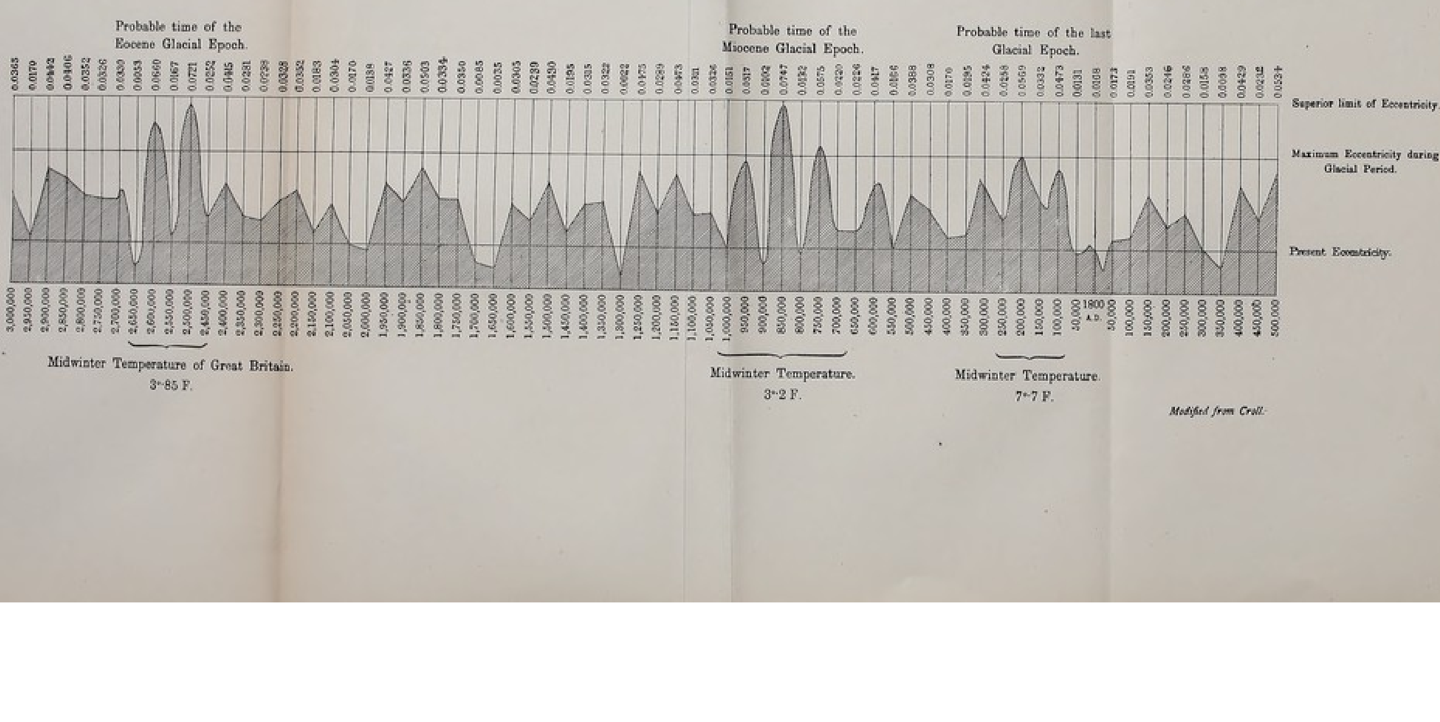
On the other hand, eccentricity being still at its maximum, if in winter this northern hemisphere were in the perihelion of the earth's orbit it would be 5,800,000 miles nearer to the sun than it is at present. The difference between winter and summer in this country would be trifling; we should have a perpetual summer temperature whilst the southern hemisphere would have a perpetual winter temperature.

As human life does not extend much beyond eighty years, no one living has had any experience of changes in climate such as are now being considered, nor can any one realize what the effect would be were continual heat or continual cold to last for thousands of years judging merely by our present winter and summer changes. The only positive means we have of ascertaining that such occurrences have taken place is from the unearthing, in countries now neither tropical nor arctic, of buried bones of animals which are only known to us as denizens of such climates.

In "Climate and Time" Mr. Croll has given a table of eccentricity of the earth's orbit for three million years in the past. He supposes that in this period of three million years three great Glacial

sun's rays : 278° :: 837 sun's rays : x. Hence $x° = \frac{278° \times 837}{1000} =$ 232° F. above that of space 850,000 years ago, *i.e.* −7° F. for mid-winter temperature of this country at that time.—Croll.

Diagram to represent the Variations in the Eccentricity of the Earth's Orbit for Three Million Years before 1800 A.D. and Half a Million after it.



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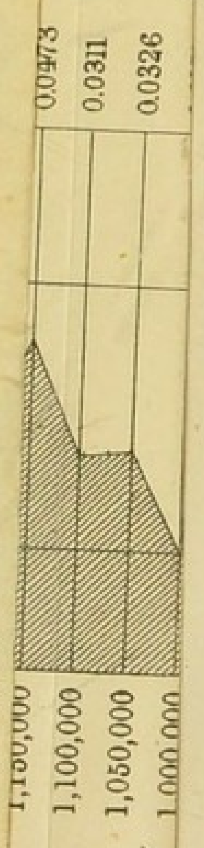


Mid

epochs are comprehended—the Eocene, which took place between 2,650,000 and 2,450,000 years ago; the Miocene, between 1,000,000 and 700,000 years ago; and the last Glacial, between 250,000 and 80,000 years ago. For these three Glacial eras he has tabulated the excess of winter over summer days; the number of degrees midwinter temperature was lowered; and the midwinter temperature of Great Britain—for intervals of 10,000 years.

The average duration of the Glacial eras, the excess in winter days and the lowered temperature in each of the three periods is—

Glacial period during	Excess of winter over summer in days.	Degrees mid-winter tempera-ture is lowered.	Midwinter tem-perature of Great Britain.
The Eocene era, 200,000 years...	... 24·75 ...	36·45 F. ...	3·85 F.
The Miocene era, 300,000 years...	... 23·25 ...	34·15 F. ...	3·2 F.
Last Glacial era, 70,000 years ...	... 20·39 ...	31·3 F. ...	7·7 F.

The above table, summarized from those given by Mr. Croll, shows that the three Glacial periods alluded to were progressively less severe, though the Miocene era lasted the longest, in consequence of the prolonged state of high eccentricity.

These two conditions, then, precession of the equinoxes and change in the eccentricity of the earth's orbit when combined, bring about deflection of the ocean-currents, which Mr. Croll considers to be "an agency far more potent" than any yet considered to produce alterations in the climate of the earth. What would be, he asks, "the condition of Europe were the Gulf Stream stopped and the Atlantic thus deprived of one-fifth of the absolute amount of heat which it is now receiving above what it has in virtue of the temperature of space?" Northern Europe would be in the condition in which Greenland now is, and if the North Pacific warm currents were stopped at the same time, the northern hemisphere would be "subjected to a state of general glaciation," and *mutatis mutandis* if these northern warm currents were transferred to the southern hemisphere the ice there would disappear uncovering the land now buried; and the smiling fields, forests and pastures which are our prerogative now would then be that of the inhabitants dwelling there.

Fuller information on these subjects will be found in the fourth chapter of Mr. Croll's "Climate and Time."

There are yet two other causes to be considered which influence climate and bring about elevation and depression of dry land in this hemisphere—explanatory of the remains of submerged forests known to exist along our southern coast. They are the polar ice-cap and the obliquity of the ecliptic.

The Polar Ice-cap.

Displacement of the earth's centre of gravity by a polar ice-cap is fully discussed by Mr. Croll in reference to alteration of climate. The following is a *resumé* of his argument on this subject:—

The equatorial diameter of the earth is about twenty-six miles greater than the polar, but with an ice-cap of many miles' thickness at one pole the earth becomes spherical.

The centre of gravity of the earth is adjusted in its relation to that of the entire mass both solid and liquid composing it; and if a portion of the fluid mass becomes solid at either pole, in an ice-cap, the centre of gravity will shift north or south, according to whichever pole has the greatest depth of ice; and, further, the water pulled over from one hemisphere to the other will aid the displacement of the centre of gravity. Thus there will be a rise of the sea-level at one pole and depression at the other.

The density of earth is 5·5; of ice 0·92; or 6 to 1. When an ice-cap of 6000 feet in thickness exists the centre of gravity is shifted about 500 feet north or south. If the ice-cap were of the density of earth the centre of gravity would then be shifted 3000 feet.

Entire transference of the ice-cap from one pole to the other would produce a submergence of a thousand feet; but probably the ice-cap would never extend beyond 55° of latitude, so that the centre of gravity would be further removed from the earth's centre than if it extended down to the equator.

Supposing, then, that there is an ice-cap of 6000 feet, the rise of the sea-level at one pole and its depression at the other will be approximately 380 feet.* That such an effect should take place is not improbable when we remember that a cubic foot of water weighs 62 pounds; and that in a high tide of ten feet there will be 620 pounds to every square foot of surface, or eight million tons in a square mile. Hence the effect of such a volume of water when multiplied by several thousands of square miles is readily apparent.

The Antarctic continent extends to 70° S. lat.,

* The change in sea-level is by Sir W. Thomson, F.R.S., calculated from this formula: $\frac{(1-z)\,it}{1-z\,w}$, where t denotes thickness of ice crust at the pole; i the ratio of the density of ice; w the ratio of sea-water to the earth's mean density; and z the ratio of the area of the ocean to the whole surface.

If $z=\frac{2}{3}$ and $t=6000$ feet; $\frac{1}{6}$ and $\frac{1}{5\frac{1}{2}}$ as the densities of ice and water respectively, the rise of sea-level at one pole and depression at the other will be—

$$\frac{\frac{1}{3}\times\frac{1}{6}\times 6000}{1-\frac{2}{3}\times\frac{1}{5\frac{1}{2}}} = \text{approximately 380 feet.}$$

and consists of highlands and mountains which attract moisture. Its radius is 1400 miles. Like Greenland the whole of this continent is covered with one continuous ice-sheet, gradually thickening inwards from its edge to its centre. In Greenland, explorers have found that the ice-plain slopes upwards towards the interior at the rate of one mile in every fifty-eight; consequently Antarctic ice which extends over an area one dozen times larger must be very thick; and if continued at the same rate for 1400 miles will give twenty-four miles as the thickness of ice at the south pole.

The snow-fall in the Antarctic circle is estimated at 30 feet per annum, and there is perpetual snow at a sea-level of 64° lat.; hence the snow-fall must be great and the yearly increment through thousands of years produce a vast result. The icebergs in this region have been found more than a mile in thickness, which indicates the thickness at the edge of the ice-cap. For every foot of ice above water there are 8·7 feet below. So that an iceberg 400 feet high has 3480 feet below water.

If the Glacial era was brought about by an increase of eccentricity of the earth's orbit, then as ice accumulated, a submergence of land was a physical necessity—not only was the land once, but several times under water, sometimes higher sometimes lower than at present. Hence oscillations of sea-level may have resulted from a transference of ice from one hemisphere to the other.

If 25·5 feet of ice were melted off the Antarctic ice-cap the general level of the ocean would be raised one foot.* And if a mile in thickness were melted the level of the ocean would be raised about 200 feet. If two miles of ice were removed from off the Antarctic continent the centre of gravity would be displaced 190 feet; and if one mile of ice were formed on the opposite pole the centre of gravity would be carried 95 feet further. But one mile in thickness melted raises the ocean's level about 200 feet, and this added to the former will give a total displacement of 485 feet.

This submergence is on the hypothesis that the earth is solid to its centre. But if it be assumed that the earth consists of a fluid interior surrounded by a rigid and thick crust the submergence will be greater. For then the interior of the globe will consist of materials of different densities and the transference of the ice-cap from one pole to the other will only displace the ocean. Within the interior the densest materials will be at the centre and the least dense outside. An ice-cap, therefore, will not only displace the ocean but the heavier materials inside;

* The Antarctic ice-cap is equal to an arc $\frac{1}{23 \cdot 46}$ of that covered by the ocean. The density of ice is 0·92 that of water is 1; therefore, $25 \cdot 5 \times 0 \cdot 92 \div 23 \cdot 46 = 1$ foot.

that is, the heavier materials will be attracted more forcibly by the ice-cap than the lighter. Thus, then, there are three causes tending to shift the centre of gravity—(1) the ice-cap; (2) the displaced ocean; and (3) the displaced materials in the interior.

But displacement of the dense materials in the earth's centre probably does not take place. For the pressure near the centre of the earth upon the melted magma will amount to about 45,000,000 pounds per square inch. On the supposition that the earth's crust is twenty-five or thirty miles thick, the liquid would be so much compressed—it will possess a viscosity so extreme—that the mass would have the same relation to extraneous forces as a very rigid solid body would have.*

This oscillation of sea-level throws light upon the geographical distribution of plants and animals. When there was an ice-cap on the southern hemisphere, the northern hemisphere would be warm; the North Sea and Behring's Straits dry land, and inhabited by the lion and similar animals. Greenland was then free from ice and the arctic region enjoyed a mild winter.

Obliquity of the Ecliptic.

The ecliptic is the plane in which the earth revolves round the sun. The plane is inclined at

* Mr. Osmond Fisher, quoted in Daniell's "Physics."

an angle to that of the earth's equator. The angle is termed the obliquity of the ecliptic. Its limits are 24° 35′ 58″ and 21° 58′ 36″, so that 2° 37′ 22″ is the amount of difference between the greatest and least declination of the earth towards the sun. The solstices are the mid points between the vernal and autumnal equinoxes. At our summer solstice the northern hemisphere is inclined 23° 17′ 17″ towards the sun to the full extent of its present obliquity, and similarly to that extent is the south pole turned away. In our winter solstice (perihelion) the northern hemisphere is inclined to the same extent *from* the sun, and the south pole *towards* the sun. Instead, then, of speaking of the sun going north and south of the equator, it is the equator which goes south and north of the sun supposed to be a fixed point.

Owing to the attraction of the planets, the axis of the earth's rotation is slowly changed in its degree of inclination to the ecliptic. At present it is growing less by 48″ per century and the long day and long night at each pole is being shortened. If the inclination disappeared and the axis of rotation became parallel or coincided with the ecliptic there would be a perpetual equinox. Hence a change in obliquity from maximum to minimum will influence the climate of the poles and tend to neutralize a high degree of eccentricity, besides which the earth will receive additional heat-rays from the sun.

When the obliquity of the ecliptic is at its superior limit, the poles—being turned more towards the sun than at present—will receive $\frac{1}{18}$ more direct heat and the temperature will be increased to more than 7° or 8°, or perhaps nearly double that amount, "provided, of course, that this extra heat was employed wholly in raising the temperature." This would happen if the poles were free from ice and snow, but if not the extra heat would only melt the snow and ice and the temperature would remain at 32° F.

The general effect of change in the obliquity of the ecliptic upon the polar regions, when combined with effects resulting from eccentricity of the earth's orbit, would be—

"When the eccentricity was at a very high value, the hemisphere whose winter occurred in aphelion would be under a condition of glaciation, while the other hemisphere, having its winter in perihelion, would be enjoying a warm and equable climate. When the obliquity of the ecliptic was at a maximum, and $\frac{1}{18}$ more heat falling at the poles than at present, the effect would be to modify to a great extent the region of glaciation in the polar zone of the hemisphere under a glacial condition, and, on the other hand, to produce a more rapid melting of the ice on the other hemisphere enjoying the equable climate. The effects of eccentricity and obliquity thus combined would probably completely remove the polar ice-cap from off the latter hemisphere, and forest trees might then grow at the pole. Again, when the obliquity was at its minimum condition and less heat reaching the poles than at present, the glaciation of the former hemisphere would be increased and the warmth of the latter diminished." *

Alteration of the sea-level is also an effect of change in the obliquity of the ecliptic when combined with increased eccentricity. About 11,700 years ago the northern hemisphere was in aphelion, eccentricity at a high value and the Gulf Stream probably less considerable than at present; this combination would lower the temperature 10° or 15° as compared with the present time. The annual amount of heat received from the sun at the pole would be greater than at present, but it would only be employed in melting the ice and would not raise the temperature. But the southern hemisphere being in perihelion would have its ice decreased, for the effects of eccentricity would not be compensated by those of obliquity as in the northern hemisphere, so that both causes would assist to melt the ice in this hemisphere. Added to which the warm

* Croll.

currents flowing from equatorial regions towards the south pole would be increased and further assist in melting the ice, whilst in the northern hemisphere the diminished Gulf Stream would not assist materially in that process. The real and effective cause, then, of the disappearance of ice in this hemisphere was the transference of equatorial heat from the northern to the southern polar region.

The total result would be an addition of water to raise the general level of the sea, and by the removal of ice the centre of gravity of the earth would be shifted to the north of its present position, and the sea level in the northern hemisphere would be about twenty-five feet above its present level. About sixty thousand years ago the rise was still more considerable—perhaps forty feet.

For fuller information on all these subjects Mr. Croll's work on "Climate and Time" should be consulted; his principal facts and arguments have alone been brought forward to show that growth and distribution of flora and fauna upon the globe depend upon changes in climate, and that one important cause of change is the transference of equatorial heat to the poles, first in one hemisphere and then in the other.

CHAPTER VI.

HAECKEL'S PEDIGREES—FIRST DIVISION.

PROFESSOR HAECKEL describes the history and development of life under three heads—the animal kingdom, the vegetable kingdom and the vegeto-animal kingdom. The following outline of the subject is compiled from his "History of Creation" and "Evolution of Man." This epitome is intended to bring together succinctly the main points of his argument in unfolding the science of evolution of the human race; but for illustrations and further details the volumes above mentioned should be consulted.

All three kingdoms, says Professor Haeckel, spring from Monera—simple, soft, albuminous lumps without structure or form—composed of carbon, hydrogen, oxygen and nitrogen. This is protoplasm, a complex nitrogenized carbon compound which he terms plasson or primitive slime—the oldest material substance in which all vital activities are embedded. In the lowest depths of the sea such homogeneous amorphous protoplasm lives under the name of

Bathybius; a Moneron discovered by Huxley. Bathybius is tinged intensely by carmine in ammonia solution. It contains fine grey refracting granules, also oleaginous drops soluble in ether and has marked amœboid movements. It is composed of a naked network of protoplasm upon which if fine mud is deposited the latter consists in great measure of "living slime." Huge masses of such slime nets crawl upon the deepest bottom of the sea.

The Vegeto-animal or Protista Kingdom is a mixture of animal and vegetable properties; it is the kingdom of primary creatures.

All sea-water contains a certain quantity of organic matter in solution and suspension, for the sea is full of animals constantly dying and decaying so that organic matter is appreciable. All the protozoa absorb or extract silica, carbonate of lime and organic matter from sea-water. Certain animal forms may have the power of decomposing water, carbon dioxide, and ammonia and reforming or recombining these elements into organic compounds without the agency of light.

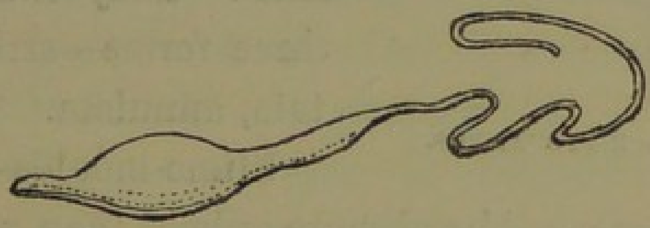
Among the Protozoa, the Ray-streamers or rhizopods—like the corals of shallower zones—formed huge accumulations of carbonate of lime. The deep beds of carboniferous limestone are formed by accumulations of skeletons of the Crinoidea, the stem-joints and cups of which are cemented together by lime sediment. The crinoidea were abundant in the Silurian epoch.

The Monera—Rhizopoda and Sponges—are the simplest of marine invertebrate groups at great depths. The monera are moving expansions of jelly-like protoplasm. They pass into Rhizopoda which have graceful calcareous shell-like structures, which become entangled and are borne along in the viscid stream of bathybius. These Monera are minute, calcareous oval bodies; first seen is an oval disc 0·01 millimetre in length with an oblong rudely facetted elevation in the centre and a kind of frill of organic matter around with a short neck, and secondly a smaller flat disc like that at the back of a stud. They are termed "coccoliths" by Huxley. A large number of the organisms whose skeletons are mixed with globigerina ooze at the sea bottom live on the surface of the sea, and when they die their delicate siliceous or calcareous spines fall gradually to the bottom. "Coccoliths" are joints of a unicellular alga living on the sea's surface and mixed with bathybius. Also upon and along with this bathybius are foraminifera, rhizopods, radiolarians and sponges. It is not impossible that a great deal of bathybius may be a kind of mycelium—a formless condition connected with the growth and multiplication or with the decay of many different things.*

* "Cruise of the *Challenger*."

Amœbæ.—These may be considered as the second stage of this kingdom. In a drop of water an Amœba appears as a roundish body with an irregular and varying form—crawls about by finger-like processes projected from the end of its body which it draws after it. Touched by a needle or acid it at once resumes its spherical form by contraction. If the water is impure it encases itself in an homogeneous capsule which hardens. It lives by imbibition and after a time reproduces itself by division.

Whip-swimmers—Flagellata—are masses of protoplasm with a round cellular kernel and central speck, and a thread-like lashing whip; they are closely aliied to both plants and animals, and are



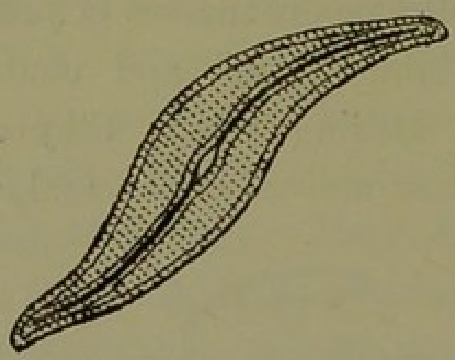
EUGLENA STRIATA.

found in fresh water as well as salt water. Under the name of Euglena they form the green of ponds. The flint-shelled yellow Peridinia are largely active in causing the phosphorescence of the sea.

Flimmer-balls—Catallacta—are pear-shaped cells with thin-pointed ends united in the centre. They form balls thirty or forty in number surrounded by a fringe. After a time they dissolve partnership and swim about by their fringes independently, like fringed infusoria, on the surface. Afterwards they sink to the bottom, draw in their fringes and change into the form of creeping amœbæ.

Tram-weavers—Labyrinthuleæ—are spindle-shaped cells of a yellow ochre colour, sometimes united into a dense mass. They form a retiform frame of entangled threads upon which the cells glide about in a way peculiar to themselves.

Flint cells—Diatomeæ—inhabit the sea and fresh water. Their soft cell-substance is brownish yellow enclosed by a solid and hard flinty shell. They exist under three forms—striata, vittata, annulata.



NAVICULA HIPPOCAMPUS.

Slime-moulds—Myxomycetes—are considered more animal than vegetable. They form roundish bladder masses, several inches in size, and are filled with fine spore-dust and soft flakes, like puff-balls. They swim about at first in the form of Flagellata, afterwards creep about like the Amœbæ and finally combine to form large masses of "slime." Out of these arises the bladder-shaped fruit-body on a stalk. They are the soft masses seen in tan yards and in damp forests on decaying vegetation.

Ray-streamers—Rhizopods, *i.e.* root-footed. There is an immense variety of their forms swimming on the surface or creeping at the bottom of the ocean. A few are found in fresh water. The majority have solid calcareous or flinty shells. In a fossil state they have accumulated to form mountain masses. Individually they are to the naked eye scarcely visible; a very few attain the diameter of a few lines. Exceedingly fine threads of protoplasm radiate from the entire surface of this naked, slimy body; these rays are quasi-feet or pseudopodia which serve for locomotion. There are three chief forms—

The Acyttaria or Chamber-shells are the simplest form. The shell may be a single chamber, bell-shaped, tubular or snail-like; or of several chambers in a row one behind the other, in concentric circles or spirals as found in the nummulites.

The Heliozoa are fewer in number and are a transition state to the next class.

Basket-shells—Radiolarians—are little masses of of sarcode tending when irritated to form a sphere. The sarcode consists of rounded or oval granular masses of brownish or yellowish colour—interspersed with oil cells, bright yellow and refractive, cemented together by soft transparent sarcode; near the centre of the body is a mass of bioplasm coloured by carmine. At rest soft sarcodic matter radiates round in straight pseudopodia. Siliceous spicules may be disposed in an irregular network over the surface like sponge. They exist at great depths where shells of the foraminiferæ, which are of calcareous nature, do not occur.

The majority of the Protista live in the sea, either at the bottom or top, some in fresh water and a few on land as the slime-moulds. In nutrition and propagation some are more allied to plants, others to animals, and all are non-sexual.

Simple naked cells with a kernel occur among real plants as well as animals. The presence or absence of an encircling hard membrane is an important difference between animal and vegetable cells. Vegetable cells at an early stage enclose themselves within a hard, thick and solid cellular shell. They are more independent and less accessible to external influences than soft animal membrane. Hence they do not combine for the construction of nerves and muscular tissues as do animals cells; nor yet receive solid particles of nourishment into their interior as is done by the ancient single-celled animals, but are only nourished by diffused fluid nutriment.

These first forms then all possess the attributes of free locomotion and exhibit irritability. Their "secretive skill" is a result of "inherited adaptation" which teaches how the bodies of animals and plants, most different and complicated in cell forms, are produced from primeval slime.

CHAPTER VII.

HAECKEL'S PEDIGREES—SECOND DIVISION.

THE vegetable kingdom is divided into two great divisions—*flowerless* plants and *flowering* plants.

Flowerless plants are technically called cryptogams, κρύπτος (hidden), from their mode of reproduction by spores, or acrogens, ἄκρος (pointed), from their mode of increasing in length by addition to the end. These are further separated into—

Thallus plants, θάλλος (sprout or sucker), are composed of simple cells; they are all aquatic.

Mosses. Aërial.

Ferns. Aërial.

They have different degrees of organization. The *lowest* or most incomplete are nothing but slender simple jointed threads, or even powdery matter.

The *intermediate* are a mixture of stem and leaf—in their expansions called a thallus.

The *highest* or more complete have both stems and leaves, and even a peculiar sort of wood.

Flowering plants are divided into two classes—

gymnosperms, γύμνος (naked), and *angiosperms*, ἀγγεῖος (a vase or vessel). These two classes are further subdivided into *exogens* or dicotyledons with an embryo with two young leaves and *endogens* or monocotyledons whose embryo has only one young leaf.

SCHEME OF VEGETABLE DEVELOPMENT.

Flowerless Plants.

Thallus Plants.		*Mosses.*	*Ferns.*
Tangles (algæ).	Inophyta.		
First Tangles.	Moulds.	Liver Mosses.	Leaf Ferns.
Green ditto.	Lichens.	Leaf ditto.	Shaft ditto.
Brown ditto.	Fungi.		Water ditto.
Red ditto.			Tongue ditto.
Moss ditto.			Scale ditto.

Flower Plants.

Naked-seeded (gymnospermæ).			*Cover-seeded* (angiospermæ).			
Palm Ferns (cycadeæ).	Needle leaves (coniferæ).	Meningos (gnetaceæ).	One Germ leaf (monocotylæ).	Two Germ leaves (dicotylæ).		
				Cup flowers.	Star flowers.	Bell flowers.

Commencing at the Laurentian epoch, it is found that algæ or tangles are the beginning of vegetable life and contain the originals of all other groups of plants. This class may have formed a part of our coal-fields. Here in the scheme are shown five different kinds of tangles, successive developments. All these different kinds exist at the present day, and all are aquatic.

Primeval Algæ, the simplest and most imperfect of all plants. They are submersed plants.

Green Tangles are hair-weeds, green slime-balls; a few are found in fresh water.

Brown Tangles are the largest and longest. On the coast of California they attain four hundred feet. The bladder-wrack which floats on water by air-bladders belongs to this class. The Sargasso Sea which occupies 40,000 square miles in the Atlantic is thickly matted over with this alga.

Red Algæ are harder; some are found in the Silurian, Devonian, and Coal formations.

Moss Tangles arise from the green tangles, as do the brown and the red.

Inophytæ, or thread plants, take their origin from primeval algæ. They are divided into *fungi* or *moulds* and *lichens,* and are closely related but distinct from higher plants. They consist of soft felt-like bodies of threads or chains of cells. The *fungi,* like animals, live upon organic food consisting of a complicated combination of carbon assimilated by other organisms. They inhale oxygen and give out carbonic acid, but never form leaf-green (chlorophyl) or starch.

The Lichens are composed of two distinct plants—a low form of alga and of a parasitic form of fungus, the latter a parasite upon the former and receiving the nutritive substances prepared by it. The green cells belong to the alga; but the colourless threads, densely interwoven, which form the principal mass of the body of the lichen, belong to the parasitic fungus. They form coverings to stones, barks of trees, etc. Their colour varies. They can settle in the most barren localities on naked rocks, as black lava. Their decaying bodies form the *first mould* in which mosses, ferns and flowering plants afterwards take root. They are found on the highest mountains.

This class of plants is not known to exist before the primary era and is the earliest aërial.

Primary Era.

This period ushered in the first aërial plants. The Inophytæ last described are the originators of mould.

Mosses and Ferns resemble thallus plants in the absence of flowers and seeds. Each kind exhibits a peculiar and characteristic alternation of generation in the course of their individual development. For every species exhibits a Fore-growth and a Cormus or actual stem of the moss or fern. The first original generation, the Fore-growth remains as such, stem and leaf-organs are not differentiated. The second and more perfect generation of Mosses and Ferns—the Stem or Cormus—develops a body which has differentiated into stalk and leaf. The third is like the first, the fourth the second, and so on. Mosses are inferior in development to ferns and originate from green tangles.

Mosses.—Liverworts are small and insignificant. Leaf-mosses are the most known, and are found in our woods or with liverworts (which are found in moist shady places over-running neglected gardens); and lichens cover the bark of trees. *Mosses act as reservoirs* for storing up moisture and are of great service in the economy of nature. The cutting down of forests robs the ground of a useful store of moisture. In this way once-flourishing and rich tracts of land are converted into dry and barren wastes.

Ferns arise from extinct mosses. They are found in the Devonian, Coal and Permian strata, where they predominate. They were developed out of liverworts in this, the Primary, period.

In 1855 one thousand species of Palæolithic plants were known, of which 872 were ferns; 77 gymnosperms (pines and palm ferns); 40 thallus plants (mostly algæ) and about 20 stem-plants not accurately definable. The five varieties may be considered together. The *leaf* and the *scale* ferns are the most important and the richest in forms. The *shaft* ferns (equisetaceæ or horse-tails) are the only remnants of the calamariæ which at this period existed as gigantic trees. These forms contain a great deal of flint.

Water ferns have few fossil forms; the oldest are found in the Jurassic system. The *Tongue* ferns arose out of leaf ferns. The scaled form belongs to the order of club mosses (lycopodiaceæ), and next to the leaf ferns, formed the largest part of the primary forests.

The largest club mosses are now found in Sunda Island twenty-five feet high and six inches thick. But Lepidodendreæ and Sigillariæ were important orders of this class—splendidly straight, unbranching trunks which divided at the top into numerous forked branches, from forty to sixty feet high and twelve to fifteen feet in diameter.

Secondary Era and Flowering Plants.

Gymnosperms are as characteristic of this period as were ferns of the Primary, and angiosperms of the Tertiary period.

The fossil remains of cycads, conifers or pines are found in coal, hence the transition took place possibly in the Devonian period. At the present day Palm ferns are scantily represented, and in external form resemble palms as well as tree ferns—adorned by a crown of feathery flowers. The best examples are the Zamiæ, or coniferous ferns; Encephalartos or thick-trunked bread-tree, and Cycas or slender-trunked Caffir bread-tree.

The lowest forms of exogenous trees are pines; they are termed Monochlamydæ (Μονος, χλαμυς, only, and loose warm cloak), or Apetalæ, because their calyx and corolla were as yet not differentiated. And from these the transition to leafy forests is gradual.

The first undoubted fossils of plants with enclosed seeds are found in the Chalk strata. Angiosperms are divided into one-seed lobed plants and two-seed lobed plants. Both kinds are found in the Chalk. Gnetaceæ or meningos are the transition group from coniferæ to angiosperms. The coniferæ up to this day have a greater variety of forms than the palm ferns or cycadæ.

It is probable that dicotyledonous plants developed out of the gnetaceæ, but that the monocotyledonous plants (one-seeded) developed later out of the dicotyledonous.

The Monocotyledons each consisted of a whorl of flowers (three leaves), simple leaves traversed by straight lines, *e.g.* rushes, grasses, lilies, irids, orchids, water onions, sea grasses; and Aaroideæ and Pandaneæ, or bananas and palms. This class is difficult to recognize among fossil remains, and it is doubtful whether monocotyledons originated in the Trias, Jurassic, or Chalk period. At all events they existed in this last period, as surely as did the dicotyledons.

Tertiary Period.

This is the period of the highest development of the vegetable kingdom. The blossom in place of being composed only of three leaves as in the monocotylæ is now composed of four, five or a multiple of these numbers. The leaves are more highly differentiated, are veined and more composite than the last. Their lowest division it has been seen had neither calyx nor corolla (hence termed apetalous) and existed during the Triassic and Jurassic periods—birches, willows, alders, poplars, beeches and oaks all bearing catkins (*i.e.* a spike consisting of imperfect flowers); also plants of the nettle kind—nettles, hemp, hops, figs, mulberries, elms, spurges, laurels, amaranth and the cup-flowers.

In the Chalk period the group with corollas appeared and grew out of the last by the simple cover of the blossoms of the latter becoming differentiated into corolla and calyx.

The star-flowers are the least perfect of the Corollifloræ, as seen in the umbelliferæ, cruciferæ, ranunculaceæ, crassulaceæ, mallows and geraniums; also roses, fruit trees, clover, broom, acacia and mimosa. In all these the blossom leaves remain separate and never grow together as in gamopetalæ (bell-flowers).

Gamopetalæ are the highest and most perfect group; the blossom leaves grow together in a more or less perfect tubular flower—seen in the convolvulus, primrose, heath, gentian, honeysuckle, olive, privet, elder, ash, the labiatæ and the compositæ. All this group developed out of the Diapetalæ in the Tertiary period, whereas the star-flowers appeared along with the Apetalæ in the Chalk period.

Thus in each succeeding later division of the organic history of the earth, the vegetable kingdom rose to a higher degree of perfection and variety.

CHAPTER VIII.

HAECKEL'S PEDIGREES—THIRD DIVISION.

As the lineage of both the vegetable and vegeto-animal kingdoms has been traced from simple soft albuminous lumps without structure or form, composed of carbon, hydrogen, oxygen and nitrogen, so this, the third and highest, form of life commenced precisely in the same way. On the one hand a purely vegetable form, and on the other a purely animal form developed from primeval slime; whilst in the vegeto-animal or protista kingdom lowly forms are still found which present a mixture of animal and vegetable properties which never develop further.

The most ancient ancestral forms of living animals were simple organisms of the lowest grade which originated from organic matter and became endowed with life. How this life was acquired has baffled philosophers in all ages and at present seems as far from solution as ever; nevertheless it need not prevent discussion on the development of living matter.

Adaptation, through practice and habit to that changing of external conditions of life, has ever been the cause of changes in the nature of organic species; the transmission of their modifications constitutes heredity. The struggle for existence in nature evolves new species without design, just as the will of man produces varieties by cultivation with design. A couple of years ago some poppy seed was sown in my garden which for two years brought forth single flowers, but last year the seeds from these flowers have produced double flowers. Instead of emptying the fine ashes from the fire-grate into the dustman's cart they were worked into the garden; by means of which it is presumed the soil became enriched and the change was brought about.

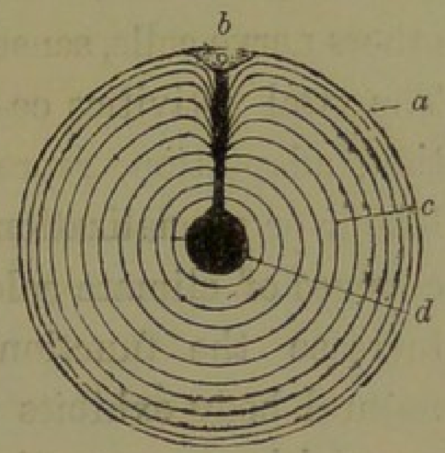
In tracing animal and also vegetable development, it must not be lost sight of that in early ages the sea and land had a very different temperature to that which they now have, so that primeval forms multiplied at a prodigious rate; as great progress would be made in one hour then as would take several hours or perhaps days to effect at this period. Even now any observant person may notice that in hot or tropical climates lowly animals soon come to maturity.

After the capture of Canton in 1857 a hospital for wounded Chinese was established in that city. It was noted that a wound dressed at 9 a.m.

would by 3 p.m. be swarming with maggots. These arose probably from the larvæ of flies which buzzed about and dropped their eggs during the morning dressing. When a wound or sore was healing the maggots were fat, large, of good cream-colour, moderately few in numbers and lazy in movement. But when the patient was to die, sometimes days before there were any appreciable signs or symptoms to denote change in constitution, the maggots faithfully indicated the condition. They became lean, small, dark in colour, more numerous and active in movement (only apparently so from diminution in size). The daily change was gradual but none the less significant; towards the close of life they became very small and almost black in colour. Thus were they of fatal import and unfailing indications of dyscrasia. The same remark applies also to the increase of lice in certain cases which were under observation in the same hospital.

Cells therefore in hot climates increase rapidly and change according to surrounding conditions; if this be true for the present time how much more was it true some twenty or thirty millions of years ago.

"In every cell the essential functions which constitute the idea of 'life' are present, viz. feeling or sensitiveness, motion, nutrition and reproduction." Later by division arise a multitude of cells from which the many-celled organism—an individual of a higher order—is developed. In the egg of a bird we have a many-celled organism from which the future individual is produced. The yellow nutritive yolk of an egg is composed of many concentric strata (c) surrounded by a yolk-membrane (a); at the upper part is the nucleus or cell-kernel embedded in a small mass of clear so-called white yolk, known as the tread (b), a thin cord of this white yolk passes into the centre of the yolk (d) when the egg is to be hatched. There is no anatomical difference between the egg of one animal and that of another, so that until it is hatched it would be impossible to say what creature would emerge. The eggs of mammalia do differ from those of birds, but this need not be entered into. The fact remains that eggs at their very earliest production are indistinguishable.



Suppose, says Professor Haeckel, a man and woman cast on an island devoid of resources, and for centuries their descendants only living for the sake of self-preservation and reproduction. Hunger and love seem to be the only motives of action in the first instance, but gradually as families collected, communities would arise. There would be a rude division of labour—hunting, fishing, agriculture, religion and medicine as pursuits would take place —then barter and so forth. Some process like this millions of years ago began among one-celled forms followed by many-celled forms. Some cells became intestinal, some muscle cells, some bone cells, others nerve cells, sense organs and reproductive cells. The vital activities co-operating—viz. growth, nutrition, adaptation, reproduction, heredity, division of labour or specialization, atavism and coalescence—in changes of climate colder or hotter, would lessen or increase the functions undertaken. Wherever a natural body exhibits the active phenomena of life* —nutrition, propagation, spontaneous movement and sensation—there is present a nitrogenous carbon compound, belonging to the chemical group of albuminous bodies which is always active; it represents the material substance through which these vital activities are effected.†

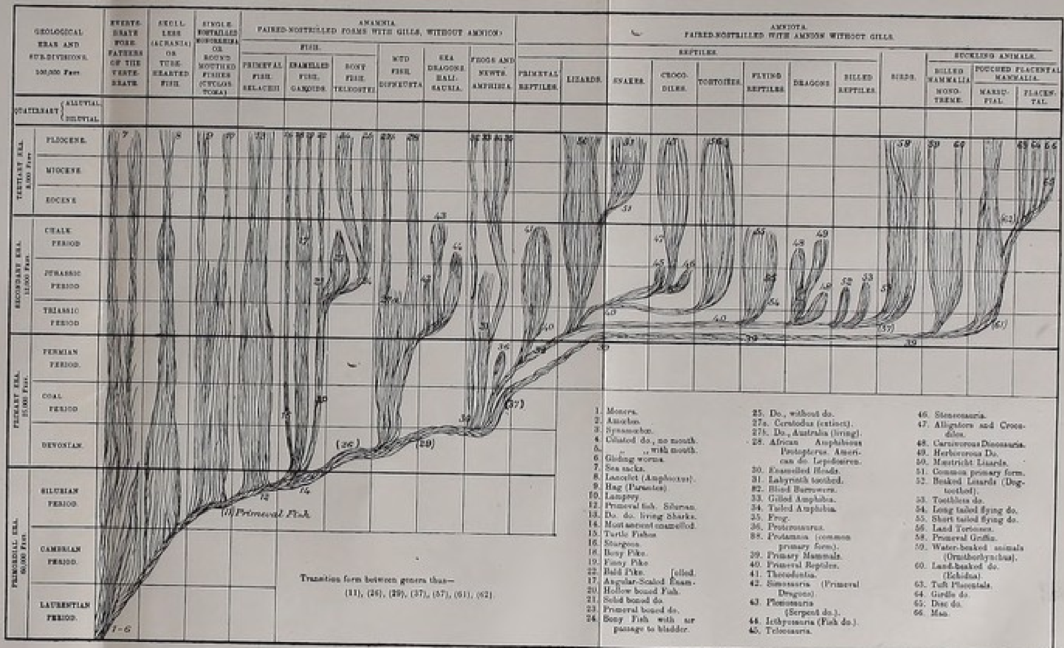
The first and oldest stage is that of Monera or Cytods—*i.e.* "organisms without organs," a kind of albuminous substance of the simplest formative material or plasson.

The next stage is differentiation of this original

* "The difference between the growth of a cell and a crystal is that the former absorbs into by intussusception, whilst the latter adds to itself externally by accretions from without."—Haeckel.

† Ibid.

PEDIGREE OF THE STEM OF THE BACK-BONED ANIMALS.



Modified from Haeckel's Plate 14, Vol. 2.

slime into two different kinds of albuminous substances—an inner kernel or nucleus and an outer cell substance. The monera then are the simplest permanent cytods which grow or increase by fission.

Amœba is the simplest form of the second stage when the cytod becomes a nucleated cell, *i.e.* a kernel and cell substance. An organized cell has originated from a structureless cell.

Synamæbæ is the next stage. An aggregation of simple cells arising from repeated self-division and permanent union of products.

Ciliated Larva.—The above aggregation becomes surrounded by fine hairs called "cilia" by which this compound cell moves about in the water; the the body is kept rotating by these cilia, or creeps at the ocean's bottom. It is globular or oval and of two kinds of cells; externally ciliated, internally non-ciliated.

Primeval Stomach Animals or Gastræada.—The compound cell of a round or an oval shape, with its surrounding fringe of cilia has advanced one step further—an inversion of the external layer has taken place to form a mouth; this inversion increases till what is termed a *gastrula* or cup-shaped animal is formed. There are then two layers of cells—the inner termed Entoderm and the outer Ectoderm. The outer layer is still covered with cilia, whilst the inner layer has none, for there is no use for them.

This cup-shaped form appears in the ontogenesis of all tribes of animals—sponges, medusæ, corals, worms, sea-squirts, radiated animals, molluscs and amphioxus, so that one germ form is common both to animal-plants and pure animal forms.

These Gastræada are divided into two branches—one which gave up free locomotion, and adhered to the bottom of the sea, giving rise to Protascus the primary form of animal plants; the other developed into Prothelmis the common primary form of worms.

Animal-plants or zoophytes have a gastro-vascular system or cœlenteric apparatus of intestinal cavity. The mouth, which is also the anus, leads into a stomach into which other cavities also open. They are mostly found in the sea—a few in fresh water such as fresh-water sponges. The original Protascus probably furnished egg-cells and sperm-cells out of its gastric layer (entoderm). Sponges have a horny skeleton, others of them a calcareous skeleton or siliceous spiculæ. Coral animals have an internal calcareous skeleton. Sea-nettles have small bladders filled with poison which burst on being touched; these are situated all over the surface. Jelly-fish and the Portuguese man-of-war are sufficiently poisonous to cause the death of man.

The Worm tribe, commencing with Prothelmis, must be thought of as a low bush or shrub out of which grew the vertebrata, star-fishes, insects and molluscs.

These three last groups take no share in the origin of vertebrate animals, and need not be further noticed.

From the primeval worm, Prothelmis, descended the first main group of bloodless worms or Acœlomi, and from these the second main group of Cœlomati —supposed to be developed at the end of the Laurentian period.

The extinct Acœlomi were flat worms. To this class belong turbellaria or gliding worms; parasitic, intestinal or sucker-worms (trematoda), and tape-worms from the last.

The group of Turbellaria is closely allied to Prothelmis which originated out of Gastræada. This group has a simple body of oval shape—no true body cavity nor blood. Hence the name Acœlomati. The surface of the body is covered with a thick, finely ciliated coat of closely-set microscopic hairs, being direct processes of the uppermost epidermic cells in constant vibratory motion. In this form the *outer* germ layer separated into two fibrous layers, one of which was muscular. The *inner* germ layer was differentiated into various organs, more especially the first formation of a nervous system (represented by nerve-threads radiating from an upper throat ganglion), the simplest organs of sense and the simplest organs for secretion and reproduction. Rhabdocœla and Dendrocœla are the nearest living representatives.

Soft Worms or Scolecida are intermediate between gliding worms and ascidians. They arose out of the last by the development of a true body-cavity (Cœloma), which formed by the separation of the skin-fibrous layer from the intestinal layer. The connecting intermediate form (extinct Bryozoa) between primitive worms and chorda animals has been lost, for having no hard parts it would leave no fossil remains.

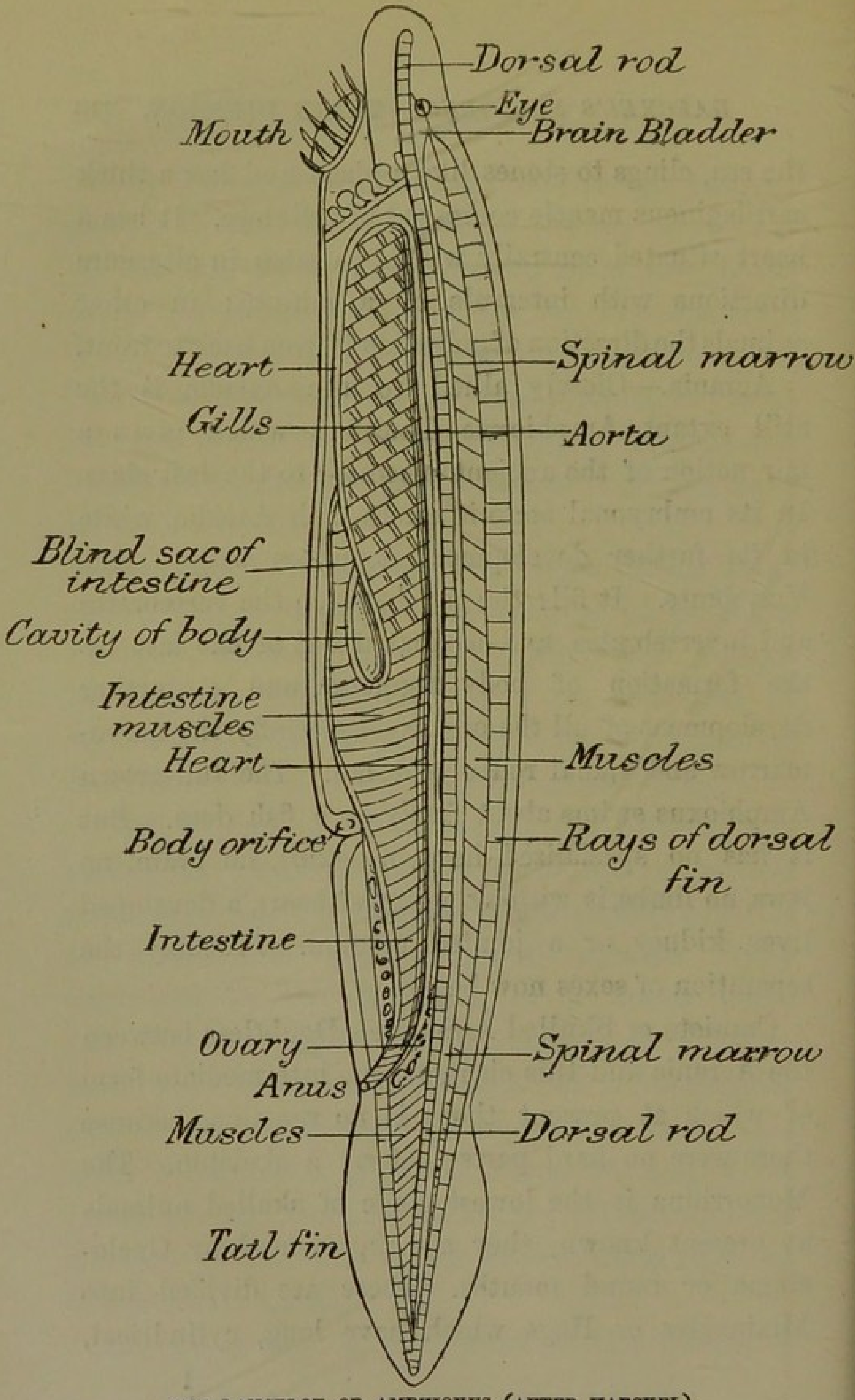
The Round Worms of the Cœlomati are principally parasitical worms; the human parasites are Trichinæ, Maw-worms, Whip-worms, etc. To the Ring-worms, whose long body is composed of segments all alike in structure, belong the Leeches, Earth-worms and marine Bristle-footed Worms.

Sack Worms or Tunicata—At the present day, among the Cœlomati, the ascidians are the nearest relations which connect the widely different classes of invertebrate and vertebrate animals. They originated by the formation of a dorsal nerve (marrow) and a spinal column beneath it. That is, there is *an axial skeleton between the spinal marrow and the intestinal canal* on the ventral side. This *is the characteristic of all the Vertebrata* and of the Larvæ of the Ascidia. Hence, of all Invertebrate animals the Tunicata are the nearest blood relations of Vertebrate animals.

The full-grown Ascidia grows at the bottom of the sea, clings to stones like a plant and has a thick cartilaginous mantle composed of cellulose. It has a heart situated centrally which pulsates in alternate directions with intervals of a minute; in other animals the direction of pulsation is from back to front.

Acrania.—Closely allied to the Ascidia is the still extant Amphioxus lancelata which gives a fair notion of the ancient successor to the last class. In its embryonal state it agrees with Ascidia, while in its further development it agrees with a true Vertebrate. It fills the gap between the vertebrates and invertebrates, and originated out of the last by the formation of body segments and a further development of all the organs—especially the nerve-marrow and spinal rod or column. The full-grown Amphioxus swims about freely as a fish does. But it has no specialized head, no skull, no brain, no jaws, no limbs, is without a central heart, a developed liver, kidney or a jointed column. Probably the separation of sexes now began.

Craniota or Skulled Animals.—Doubtless between the Acrania and this class was an intermediate form of which at present there is no remains, because there were no hard parts to form a skeleton. The Monorrhina is the lowest stage of skulled animals at present known, they are represented by Cyclostoma or round mouths. These are divided into Mixinoides or Hags which have long, cylindrical,



THE LANCELOT OR AMPHIOXUS (AFTER HAECKEL).

worm-like bodies living in the sea as parasites, they are found occasionally in the cod and sturgeon, having penetrated through the skin; and the Petromyzoa—Lampreys or "nine eyes."

The skull and brain of these animals are of the simplest form; they are expansions of the anterior ends of the dorsal rod and dorsal marrow, to form a skull and brain; they have also a simple two-chambered heart, a liver and kidneys of primitive character, a single pit in the centre of the forehead region for the nose but no jaw; this central depression gives the name Monorrhina or single-nostril. As far then as is at present known Hags ana Lampreys are the connecting link between Fishes on the one hand, and the Amphioxus, the representative of skull-less animals, on the other.

Anamnia and Amniota are the two great divisions under which animal nature can now be described.

Anamnia are forms with two nostrils, gills and no membrane investing the egg in process of hatching.

The amniota are forms with two nostrils, no gills, but a protecting membrane for the safe custody of the egg or embryo.

ANAMNIA.

Fishes have a head and a brain, with nose, eyes and ears. The brain, at first a bladder-like extension of the medullary-tube, is distributed into five consecutive brain-bladders. There are also a heart, liver, kidneys and sympathetic nervous system. The nose is double. The anterior end of the intestine is modified from the gill-intestine of the ascidians into an internal gill-skeleton, consisting of cartilaginous arches between the gill-openings within the gullet, and round the throat. The foremost pair of gill-arches becomes a maxillary-arch producing an upper and lower jaw. The blind sac protruding from the anterior part of the intestine forms the swimming-bladder which in land animals becomes the lungs. There are a pair of pectoral fins and a pair of ventral fins, the analogues of limbs but there is no trace of these either in the Acrania or the Monorrhina. A spleen and ventral salivary gland also are present.

There are three sub-classes of fish—1. Primitive fishes (Selachii)—sharks and rays.

2. Mucous fishes (Ganoides)—sturgeons and very few others.

3. Osseous fishes (Teleostei) to which belong most extant fishes and nearly all river fish.

1. The sharks, rays and sea-cats still exist, but are poor remains of this once powerful and extensive class. The skeleton was cartilaginous and still is capable of but little ossification. Teeth and fin spines are alone preserved in the upper portion of the Silurian period.

2. The Ganoid fishes are midway between primeval and osseous fishes; their gigantic remains are preserved in the Devonian rocks. There are three varieties: (1) The sturgeon is the present representative of the Mailed Ganoid fish; (2) Angular-scaled is represented by the Finny Pike in African and Bony Pike in American rivers; and (3) the Round-scaled represented by the Bald Pike in North American rivers is the only survivor. But out of this last variety arose—

3. Osseous fish (Teleostei) which include the chief portion of the fish of the present day.

In the Archizoic period the globe population was water dwelling, and the earliest fossils of land animals occur in the Devonian strata. By adaptation the lungs took the place of the gills and swimming-bladder. This produced a change in the circulation of the blood and the organs connected therewith. The swimming-bladder adapted itself to the respiration of air and became a lung. The nose and heart were also modified. Osseous fishes have two blind nose-pits on the head-surface and these were connected with the mouth by an open passage. The heart, which consisted only of an auricle and ventricle, had the auricle divided into a right and left chamber. As the skeleton of these early fishes was soft and cartilaginous it soon disappeared. Hard teeth, however, are found in the Trias which resemble those of the Ceratodus.

Mud-fishes (Dipneusta) or Double-breathers, so called because they retain the early mode of breathing with the newly-acquired lung-respiration.

The transition state between bony fish and this class is wanting. Mud-fish first appeared in the Devonian era by adaptation of the organs in use in water to life on land. They are an intermediate stage between the selachii and amphibia, and have a remote resemblance to the still living salamander fish. There are three genera of the mud-fish or early sirens now extant. (1) The Protopterus annectans in the Nile, Niger, etc.

(2) The Lepidosiren Paradoxa in the tributaries of the Amazon; and

(3) The Ceratodus Fosteri in Southern Australian swamps.

In the dry season these animals bury themselves in mud and use their lungs; in wet weather they swim like fish and use their gills. The Australian fish is six feet long, the lung is simple, the fin-skeleton pinnate. The African and American forms have a double lung and the fin-skeleton is not pinnate. The African form has external as well as internal gills, but the American has not. The lepidosiren is of the eel kind, scaly and resembles a fish more than an amphibian; but in nose, lungs and heart resembles an amphibian. It has no solid skeleton therefore there are no solid remains except teeth in the Trias formation.

Sea Dragons.—This is a formidable class of animals thirty to forty feet long; they form an isolated group —the Simosauria, Plesiosauria, and Ichthyosauria.

Amphibians.—Out of mud-fish were developed frogs and newts. Besides lungs the early amphibians retained throughout life regular gills, like the Proteus and Axolotl, and the five-toed form of foot on each of the four limbs—a less number shows that the missing toe was lost by adaptation. The paddling fins of the Dipneusta were transformed into five-toed legs, and various organs, especially the spinal column, were more perfectly differentiated. This began about the middle of the Primary period and before the Coal formation, for fossil amphibia are found in the Coal formation. They are the oldest known vertebrates with five toes. The fin which in earlier forms was multidigitate became in this class reduced from ten in the dipneusta to five in the Devonian period. The Cherotherium in the Trias has five toes or digits. Some may have fewer, but the cause was the altered function the limbs had to discharge in terrestrial as compared with aquatic life. The brain was also more developed in function and structure owing to the intimate correlation of the muscular and nervous system.

Tadpoles or the fish-like larvæ of Frogs on attain-ing a certain size undergo a transformation; a closed sac grows from the throat which develops into a pair of lungs; a partition wall divides the auricle of the heart into two chambers by which means the blood in place of being sent wholly to the gills is in part diverted to the lungs—the tadpole has thus become a dipneusta; after this the gills are lost, and the respiration is carried on by the lungs alone; later the long tail drops off and the frog then leaps about on legs which have sprouted in the meantime. The same condition of tail and gill-arches is seen in the human embryo.

The Amphibia were not fully developed till the Carboniferous era, and are the first fossil reptiles at the close of the Permian period.

The last ancestors of this race lost their gills, but retained the tail, as seen in salamanders and newts of the present day. The condition originated by breathing in early life only through gills and in later life only through the lungs. They are found in the Permian period and possibly existed in the Coal period.

An intermediate form between salamander and lizards in the early part of the Permian period was most probably developed, connecting the class of Anamniota which has now been considered with that of the Amniota, the next division.

AMNIOTA.

The unknown Protamnia originated out of tailed amphibia by the complete loss of the gills, by the formation of the amnion, of the cochlea and of the round window in the auditory organ and of the tear-glands.

The Amnion is an investing membrane for the safe custody of the embryo, it commences in the middle of the embryo and gradually envelops it; it is filled with water and encloses the germ in the form of a bladder. The gills are lost and the gill-arches modified into other organs. There is also formed another bladder, the Allantois, which holds the secretion from the kidneys; it was first noticed in the mud-fishes and is found in the lepidosiren and frogs. Besides the foregoing modifications there is in the embryo a greater curvature of the head and neck. In the former division the embryo is straight or sickle-shaped; but in this class at a very early age the back is much arched, the head placed at right angles to the chest, and the tail turned up (on the abdomen) in front.

This "skull curve," "neck curve" and "tail curve" are common to the embryos of all Reptiles, Birds and Mammals. There is no trace of gill-leaves, or real respiratory organs on the gill-arches, ever found in the embryos of this division. The gill-arches and openings are changed into jaw-apparatus and organs of hearing. The heart also has its ventricle divided into a right and left chamber. The kidneys which were originally tubes are now reconstructed.

The Comparative Anatomy of all Reptiles, Birds and Mammals agree in so many characteristics that they must be admitted to be descendants of a single primary formed called Protamnion.

From this common primary form Protamnion, three different classes of animals have been developed—reptiles, birds and mammals. In the original form protamnion, doubtless, there were degrees in developmental activity which influenced the direction in which growth took place. One form produced primitive reptiles and lizards, out of which grew snakes, crocodiles and tortoises. A second form (similar to bats) had an elongated fifth digit in the upper extremities supporting an enormous membrane for the purpose of flying, which produced flying reptiles and dragons. These were succeeded by Beaked reptiles which eventually obtained their highest development in Birds. (In the Upper Oolite birds existed with long tails like lizards and with the hand-bones of the distinct, and not melted together as in the wings of the modern bird. The old Tooth-bearing birds in this period had their clavicles distinct, as in the Emeu and embryo birds in general.) * While in a third form, direction was taken in the unknown form Promammalia.

* Parker's "Mammalian Descent."

CHAPTER IX.

HISTORY OF THE EGG.

Before considering Promammalia, it will be convenient to discuss that marvellous structure whence nearly all the information of early processes in development has been derived—the egg of a bird. It is a "complex historical product, the result of countless processes of heredity in the course of millions of years." *

It will be remembered that, in the lowest forms of animal life, reproduction of form may take place by gemmation or budding, the bud is younger than the parent organism; or, by division, *i.e.* a cell divides into two parts—these grow, again divide and so on *ad infinitum;* the products of each cell-division are equal in age.

"Protoplasm is regarded as an exceedingly complex and unstable compound, undergoing continued molecular change or metabolism. On the one hand, more or less simple dead matter or food passes into life by a series of assimilative ascending changes,

* Professor Haeckel.

with each of which it becomes molecularly more and more complex and unstable. On the other hand, the resulting protoplasm is continually breaking down into more and more simple compounds, and finally into waste products. The ascending, synthetic, constructive series of changes are termed "anabolic;" and the descending, disruptive series "katabolic." Both processes may be manifold, and the predominance of a particular series of anabolic or katabolic changes implies the specialization of the cell." * Hence, probably, sexes arose from the amalgamation of two cells from the community of the many celled organism. At first two cells may have been alike, but by increased nutrition a contrast arose; the best nourished became a female egg cell and the least nourished became a male (seed or sperm) cell.

The constructive process involves growth, so that a relative preponderance of disruption necessitates reproduction. A disruptive climax attends division, which is succeeded by a constructive period. Reproduction then begins with the breakage of living matter grown too large for successful co-ordination. "Large cells beginning to die, save their lives by sacrifice. Reproduction is literally a life-saving against the approach of death." †

* See "Evolution of Sex," by Professor Geddes and J. A. Thomson, in Contemporary Science Series.

† Ibid.

In lower plants and animals both sexes exist in the same plant—hermaphroditism. In other plants they are distinct, and require agencies to effect fertilization.

In Gastræads, where sexual differentiation is first met, there are only two primary layers. The two kinds of cells (male and female) therefore originated from cells of the two primary germ-layers. As the nutrition of cells seems to be instrumental in bringing about sexual reproduction, egg-cells (ova) are supposed to have originated from the intestinal layer as the better nourished, and sperm or male cells from the skin-layer. The earliest traces of reproductive organs are found when the skin-fibrous layer and intestinal-fibrous layer meet in the mesenteric plate.

Eggs and sperm cells exist in chalk sponges and hydroid polyps, as well as in gastræads; the same with ascidians, earth worms, leeches and garden snails. Probably also in the earliest skulled animals. But in Man and Vertebrates the original rudiments are Hermaphrodite.

In Birds, Reptiles, most Fishes, Crabs, Insects and others, both the ripe egg and the parent-cell consist of two distinct and separate parts distinguished as "formative" and "nutritive" yolk. The *formative* yolk is the nucleated cell capable of evolution, which divides in the process of cleavage to produce cells which constitute the embryo. The *nutritive* yolk is that mass of yellow, fatty matter which we daily consume as the yolk of egg, and is only a store of food for the embryo. This large yellow mass forces the kernel or nucleus of formative yolk, *i.e.* the small white circular point embedded in clear so-called white yolk or "tread," to the upper part of the yellow mass; there this "tread" remains till the egg is about to be hatched. The whole mass of white and yellow yolk has no share in the formation of the chick, it is only used as nutritive material.

When the egg of a bird is fertilized it becomes a Cytula or Parent-cell, because in the Cytod, which was a homogeneous, structureless body, a nucleus has been formed, due to the union of two cells of different power. When cleavage of yolk is spoken of this cleavage only refers to that of the "formative" part of the yolk. After cleavage has taken place a mulberry mass, called a Morula, is formed; *i.e.* an original, non-nucleated mass becomes a mass of nucleated cells. By inversion a gastrula or germ-cup  is formed, from which the future individual is developed.

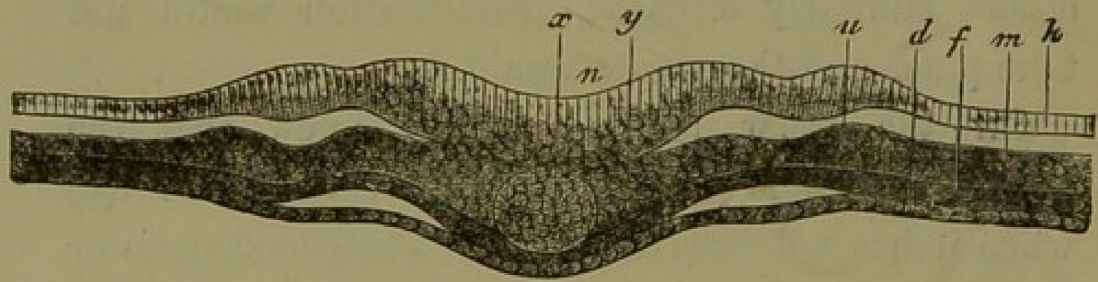
In Birds and Reptiles cleavage of the yolk is termed *partial*, because there is independent nutritive yolk set on one side for the nourishment of the chick. But in Mammals this cleavage of the yolk is *total;* that is, there is no independent yolk for nourishment; other means being provided for this purpose.

Individual existence begins at the moment of fertilization both in plants and animals. In some plants, as white clover, bumble bees are required to convey the pollen to the pistil, or else, for want of the intervention of these insects in this plant and others similarly situated, fructification would not take place and the plants would die out.

On the other hand, Aristotle knew that the embryos of bees can be developed from the egg when it has not been fertilized. Parthenogenesis or virginal generation of bees was proved by Siebold of Munich, who showed that male bees develop from unfertilized, and female bees only from fertilized eggs; hence the difference between Queen bees and workers is one of diet.

Wolff in 1768 came to the conclusion that the entire embryonic body of all higher animals as well as birds is for a while—during early incubation—a flat, thin, leaf-shaped plate which appears at first simple but subsequently is composed of several layers; and that the lowest of all these layers or leaves is the *intestinal canal.* This leaf-shaped rudiment at first forms a groove, the edges of which curve towards each other growing into a closed tube, finally a mouth and anus arise from the open ends.

Like the intestinal canal the nerve, muscle and vascular systems, with all the various organs belonging to this last, develop in a similar manner from a simple leaf-like rudiment which assumes the form of tubes. Just as occurs in plants; all the various parts of plants may be traced back to the leaf as the "fundamental" organ, flower and fruit with all their parts being developed from modified leaves.



TRANSVERSE SECTION THROUGH THE GERM-SHIELD OF A CHICK, SHORTLY AFTER INCUBATION.

h, The skin-sensory, or sensory layer; *m*, the skin-fibrous, motor or flesh-layer; *f*, the intestinal-fibrous or vascular layer; *d*, the intestinal-glandular, or mucous layer. All these four secondary-germ layers coalesce in the middle, *y* and *x*, to form the axis-band, the notochord or future spinal axis defined at *x*. The first trace of the primitive groove is at *n*; and *u* is the region of the primitive kidney rudiment.

h and *m* correspond to the Ectoderm, the outer or animal-germ layer; *f* and *d* correspond to the Entoderm, inner or vegetative-germ layer.

From *h* arises the outer skin, nervous system and organs of sense.

From *m* arises the vertebræ, skull, bones, muscles and male (sperm) cell.

From *f* arises the intestines, gills or lungs, heart, blood-vessels and female (egg) cells.

From *d* arises the liver, intestinal and other glands.

(Arranged from Haeckel.)

Baer, in 1827, showed that from the globular yolk of Mammals, first two, then four germ-layers are formed, which become modified into tubes and give rise to the first fundamental organs. The first rudiment of the body of a vertebrate is an oblong disc in the globular yolk of two leaves. From the *upper* or animal layer are produced organs in which reside the phenomena of animal life—the functions of sensation, motion and the covering of the body (skin). From the *lower* or vegetative layer all the organs which bring about the growth of the body—the vital functions of nutrition, digestion, blood-making, breathing, secretion, reproduction and the like.

Each of these two original germ-layers separates into two thinner layers, so that the whole vertebrate body is formed into a tube whose wall is composed of four layers lying one over the other.

The Vertebrate tribe originated out of the Worm tribe; it has no connection with articulated animals, to which class belong crabs, spiders and insects. The lungs are a modification of the swimming-bladder of fishes, and the original formation of all vertebrates is sexless. But the embryonic glands in vertebrates contain the rudiments of males and females, and the separation into sexes took place at a later date in consequence of improved diet.

The Ova or Eggs of different classes of animals require different periods for development. In *Birds:* the common Hen takes 21, the Duck 25, the Turkey 27, the Peacock 31, the Swan 42, the New Holland Cassowary 65, and Humming-birds 12 days. *Mammals* to produce their young take—the Harvest

Mouse 3, Rabbits and Hares 4, Rats and Marmots 5, the Dog 7, the Pig 17, the Sheep 21, the Stag 36, the Ox 40, the Horse and the Ass 43 to 45, the Camel 56, the Rhinoceros 78, and the Elephant 90 weeks.

There is no essential difference in the embryo of a mammal, a bird or a reptile. The human embryo at fourteen days is like other mammalian embryos in form, viz. a simple lyre-shaped germ-shield. At thirty days it has no distinguishing feature from that of other mammals. At the end of six weeks the various divisions of the brain are greater and the tail shorter. The eggs of the higher mammals are, moreover, exactly of the same size, $\frac{1}{10}$ to $\frac{1}{20}$ of a line [$\frac{1}{5}$ to $\frac{1}{10}$ of a millimeter].

Millions of years must have elapsed since any one of the creatures enumerated above gradually developed from a one-celled organism. Yet, as far as at present known, each one only takes the time specified.

Organic history on earth could only commence when water existed. The tissues of an adult man contain 70 per cent. of water and only 30 per cent. of solid matter. In a child the percentage of water is greater; and in the embryo the quantity of water is greatest of all, or more than 90 per cent. of water and less than 10 per cent. of solid matter. Modification, therefore, in the mode of germination must, during the millions of years in which organic life has been developing, have occurred in most animals. The higher the individual organism stands in the animal kingdom the less completely does it reproduce the entire series of its ancestors. For "the historical record premised in the history of the evolution of an individual is gradually obliterated in consequence of the fact that evolution continually strikes out a straighter path from the egg to the perfect animal, and the record is much vitiated by the struggle for existence which the freely living larvæ have to undergo." *

* Haeckel.

CHAPTER X.

THE ANIMAL KINGDOM.

PROMAMMALIA.

THE long-since extinct and unknown primary forms of Promammalia were probably closely related to the Beaked animals, Ornithorhynchus or water duck-bill and the Echidna or beaked mole resembling a hedgehog of the present day. The former differ from the latter by the teeth present in their jaws. The beak of the living animals is an adaptative characteristic which has developed at a later period. These forms arose out of Protamnia (in the Trias) by advances in their internal organization and transformation of epidermal scales into hairs, and the formation of milk-glands for the use of the young.

In Birds and Reptiles the skull is connected with the first cervical vertebra by a single-joint process of the occipital bone. But in Mammalia and Amphibia this joint-process is double, *i.e.* there are two-knobbed joints or condyles. In reptiles and birds also, the under jaw is formed of many pieces joined by a square bone to the skull, which is movable. But in mammals the lower jaw consists of two pieces articulated directly with the temporal bone.

The Skin of reptiles and birds is covered with scales and feathers which develop in hillocks *on* the skin, but in mammals hair is developed in closed follicles *in* the skin.

The Blood in reptiles and birds is red, nucleated and elliptical in form; but in mammals it is red, non-nucleated and circular in form, except in the camel and llama where it is elliptical.

The Eggs of reptiles and birds are provided with a large nutritive yolk and undergo partial cleavage; but those of mammals are very small, have no nutritive yolk and undergo total cleavage.

This advance in development probably took place early in the Secondary period, for the oldest fossil mammals are found in Triassic strata, in which reptiles are the more numerous, and mammals are of secondary importance.

Mammalia.

All Mammals including Man must be traced from a common mammalian parent-form; and there are two characteristics peculiar to this class, viz. the possession of a complete diaphragm, or membrane dividing the trunk horizontally, and milk-glands, which distinguish it from birds and reptiles.

This division of the animal kingdom consists of three distinct varieties—Billed animals or Monotremata; Pouched animals or Marsupials; Placental animals or Placentalia.*

The Billed Mammal—Monotremata or Ornithodelphia—is the oldest group and agrees with birds, reptiles and amphibia in the possession of a common vent or cloaca. This group has a well-developed Coracoid bone uniting the shoulder-blade with the breastbone—in other mammals and in man this has degenerated. This group is a direct intermediate form between the protamnia and other mammals. At present it is represented by the Tasmanian beaked-animal the Duck-billed Platypus (Ornithorhynchus paradoxus), which is web-footed, has a thick, soft skin, broad flat jaws, swims in rivers, builds subterranean dwellings and lays eggs which it incubates: another form is the Porcupine Anteater; neither form has true bony teeth. The Forebrain (or Cerebrum) is so small that it does not overhang the Hind-brain or cerebellum. It is provided with milk-glands, but no nipples. The milk exudes through sieve-like places in the skin perforated with holes and is licked off by the young.

Marsupials or Didelphia.—The characteristic of these animals is a pouch or marsupium supported by two characteristic marsupial bones.

The lower jaw has a peculiar hooked-shaped bony

* Classified by Huxley as Prototheria, Metatheria and Eutheria.

process passing horizontally inwards from the angle of the jaw. No other mammal has such a formation. Only lower jaws have been preserved in the Jurassic and Chalk formations, the rest of the body having been lost—for the jaw is easily detached and preserved in mud. The jaws of Microlestes antiquus have been found in the northern hemisphere at the bottom of the Secondary rocks.

The Kangaroo and Pouched Rats are the only representatives of this class at present, being the last remnants of an extensive group which passed through a series of stages before it succumbed in the Tertiary period to a higher and stronger class, the Placentalia.

The vent or cloaca became divided: the milk-glands developed special nipples and projected into the cavity of a pouch which was supported by the marsupial bones. In this cavity the imperfect young are carried by the mother till completely developed. In the Giant Kangaroo the young stay in this pouch after birth for a period of nine months, being nourished by the milk-glands. The coracoid bones are not united to the breast-bone; the brain is still imperfect; and the corpus callosum is feebly developed.

Placentalia.

There are no fossil remains of placental animals before the close of the Chalk period. The peculiarities of this class are that the fore-brain is more developed.

The Corpus Callosum connects the two hemispheres of the brain and in this class alone attains its full development; in the two former classes it is an insignificant rudiment. The marsupial pouch is not developed nor yet the marsupial bones; these bones, common to the former classes, arose from a partial ossification of the inner oblique muscles and tendons; they were embedded in the abdominal wall and rested on the anterior edge of the pelvis. The placenta or vascular cake is well defined and is the distinguishing feature.

The Allantois consists externally of an intestinal-fibrous layer and internally of an intestinal-glandular layer; the cavity being filled with primitive waste watery products. The intestinal-fibrous layer is traversed by blood-vessels for nutriment and respiration. In Reptiles and Birds the allantois encloses the embryo with the amnion but does not coalesce with the outer covering (chorion) of the egg. The same takes place in monotremes and marsupials. But only in this class does the allantois form a vascular cake, and it is essential, because the young are more matured before they are born than in the lower forms.

Placentalia are divided into Deciduata and Indeciduata.

The *Indeciduata* embrace Hoofed animals—the tapir, horse, swine, ruminants and the like; Whalelike animals—sea-cows, porpoises, dolphins, whales and the like. In all these the chorion-tufts (outer covering) are distributed singly or in bunches over the surface, they are loosely attached to the lining membrane of the (uterus) receptacle for the young and can be withdrawn as a hand from a glove. The two vascular cakes do not coalesce at any point in their contact. At birth the embryonic cake or fœtal placenta is alone removed, the maternal cake not being displaced.

The *Deciduata* embrace beasts of prey, rodentia, elephants, bats, semi-apes, apes and Man. In these the whole chorion (outer covering) is covered with tufts at first, which disappear from one part to be more vigorously developed on another part of the surface and alone forms the placenta. Of the Deciduata there are two forms—Girdle-shaped placentæ are found in terrestrial and marine animals (Carnivora and Pinnipedia); also in False-hoofed animals—the elephant, and the hyrax with its allies. The vascular cake in these resembles a broad ring, or girdle, embracing the central zone of the egg, in place of the two ends or poles. Discoidal placentæ are found in semi-apes, insect eaters, diggers, sloths, rodents, bats, apes and Man. The placenta forms a thick, spongy, circular or oval cake, and the embryonic egg-membrane is smooth and tuftless.

Fresh-water otters and sea otters present a direct form of transition to Seals and show how the bodies of the Carnivora were transformed by adaptation to an aquatic life, and how the steering fins of seals have arisen out of the legs of the former. They stand in the same relation to the former as do whales to hoofed animals. The river horse stands midway between the extreme branches of oxen and sea oxen, the sea otter is also an intermediate stage between dogs and sea dogs. In both cases the transformation of the external forms, consequent upon adaptation to entirely different conditions of life, has not effaced the solid foundation of inherited internal peculiarities.

Hoofed animals (Ungulata) are divided into those having pair and odd hoofs. Pair-hoofed animals comprise pigs, hippopotami, ruminants, deer and sheep. From Odd-hoofed animals have descended horses. In these latter the third toe is more strongly developed and forms the centre of the hoof. In paired hoofs the third and fourth toes are equally developed, the space between the two forming a central dividing line.

Whales probably arose out of hoofed animals which took to water and became aquatic; their internal structure agrees with the class of tufted placentæ or indiciduata.

Semi-apes (Prosimiæ) originated in the early part of the Tertiary period out of Rat-like marsupials by the formation of a placenta and development of the brain commissures; also with the loss of the marsupium and marsupial bones. They were very numerous at that period. At present, short-footed as well as long-footed Prosimiæ, are only found in Madagascar, the Sunda Islands and a few in Asia and Africa. No living or fossil species have been found in Europe, America or Australia. Probably they closely resembled the extant brachytarsi or lemurs, which lead a quiet life climbing on trees; these are nocturnal animals of a gentle and melancholy disposition subsisting on fruits, represented by the Slender Lori of Ceylon.

Insectivora in the shape of their jaws and their mode of life are akin to carnivora, but from possessing a discoid placenta and other peculiarities (male) are allied to rodents. The order probably has developed out of Semi-apes which were closely allied to the Long-footed Lemurs. "If we compare our present living Insectivora with the extinct Eutheria of the early Tertiary period, these two faunæ are manifestly similar. There is nothing in the dentition of either primates, carnivora, or ungulates which is not foreshadowed in the insectivora. It cannot be decided in a given fossil skeleton with skull, teeth and limbs almost complete whether it should be arranged with the lemurs, the insectivora, the carnivora or the ungulates." *

* Huxley, quoted by Parker.

Simiæ.

Simiæ or true Apes, were an advance in development of Semi-apes: they form two classes. In the old world the apes are narrow nosed (Catarrhinæ); in the new world they are flat nosed (Platyrrhinæ). In these last the nose is broad and flat, so that the nostrils are *in front* and not below. The still living Nose-apes and Holy-apes possess jaws and narrow noses like Man, but they have a long tail and bodies covered with hair. They originated out of the semi-apes by the transformation of the jaw. The claws on the toes as found in the older Tertiary beds were changed into nails.

The Cape toad has nails on the fingers and toes, and is the first of gill-bearing creatures in which this specialization is observed.

"The structural differences which separate Man from the Gorilla and Chimpanzee are not so great as those which separate the Gorilla from the lower Apes." * Apes are the only animals among the deciduata which share with man the following peculiarities—viz. an outer, an inner and a placental deciduous membrane, or decidua vera, decidua reflexa and a vascular cake which is part of the decidua vera modified by the intrusion of the chorion tufts.

* Huxley.

Their Teeth are also the same in number and structure; except in the American ape which belongs to another group, they have three molars and three premolars or bicuspids on each side in each jaw.

The Nose also is the same, a narrow partition of the two halves with the nostrils *downwards.*

Among the extant tailed apes, the slender apes (semnopitheci) are the most nearly related to the oldest parent-form of the Catarrhine group.

ANTHROPOIDES.

After the Simiæ came the Anthropoides or Man-like apes. They are divisible into two classes—African and Asiatic. They developed out of the simiæ by the loss of the tail, partial loss of the hairy covering and excessive development of the brain above the facial portion of the skull.

The Asiatic branch the Orang and Gibbon are found in Borneo, Sumatra and the Sunda Isles; they are mostly of a brown or yellowish brown colour. The head is short from back to front (brachycephalic).

The African variety comprises the Gorilla and the Chimpanzee; both are black in colour. The head is long from back to front (dolichocephalic).

The Orang which is said not to be adult till the age of from ten to fifteen years is nearest to man in the development of the brain. The Gibbon in the formation of the thorax. The Chimpanzee in the formation and structural details of the skull; and lastly, the Gorilla in the development of the hands and feet.

These are all scattered remnants of an old catarrhine branch once numerous, from which the human race has developed as a special branch.

The Ape-like characteristics of Man are distributed in particular parts of the body among different races, so that "each is endowed with some heirloom of this relationship." It may then be fair to infer that intellect is represented in the orang; business capacity in the chimpanzee; constructive and destructive habits in the gorilla, and vocal power in the gibbon.

Ape-like Men. Alali or speechless men.

Apes gave up the habit of climbing and assumed an erect gait. This resulted in a carriage peculiar to man in the reconstruction of the spinal column and pelvis, and the specialization of two pairs of limbs: the fore pair for grasping and touching; the hind pair for walking only. A change of food necessitated changes in the jaws and the teeth, and thus the formation of the face was altered. The tail gradually dwindled, and social habits or instincts developed; through being speechless these ape-like men had not the corresponding development of a higher consciousness and formation of ideas—man's chief characteristic. This conclusion is arrived at by studying comparative philology, and from the history of the development of language in every child as well as in every nation.

Man, then, as he is seen to-day is the complete expression of minute adaptative changes which have been going on in animal forms for many millions of years, culminating in the organ of voice.

The adult male gorilla has a laryngeal sack and a tremendous voice. The male orang has also a laryngeal sack. The gibbons are the noisest apes, and the Sumatra species has a laryngeal sack. The gibbon agilis (Hylobates) has a loud musical voice and a complete and correct octave of musical notes.*

By the gradual development of the animal language of sounds, articulate language was formed. At the same time there was a higher differentiation of the larynx, and of the brain to call this organ into use.

All human languages have developed slowly and by degrees from the simplest rudiments. The same may be said of those marks by which thoughts are conveyed—the earliest known signs being inscribed on Egyptian tombs and Assyrian tablets, if northern runes may not be of a still more ancient date.

The following table exhibits the most important stages in the lineage of Man from the lower vertebrates :—

* Darwin.

	Ancestral Stages of Man.	Nearest Living Relatives of Ancestral Origin.
PRIMORDIAL ERA.	Monera or Cytods	Bathybius
	Single-celled primæval animals	Simple amœbæ
	Many-celled primæval animals (synamœbæ)	Communities of amœbæ
	Ciliated planulæ	Planula larva
	PRIMARY INTESTINAL ANIMALS (gastræada)	Gastrula larvæ
	Prothelmis (primæval worms)	Protascus — Zoophytes
	Echinodermata and articulata	
	Accœlomi (gliding worms)	Molluscs; Rhabdocœla, dendrocœla
	Cœlomati (soft worms, scolecidæ)	Intermediate between gliding worms and sea-squints
	Sack worms (tunicata)	Sea-squints (ascidiæ)
	Boundary between Vertebrate and Invertebrate Animals.	
	Skull-less animals	Lancelets (amphioxi)
	SKULLED ANIMALS (Craniota).	
	Monorrhina (single-nostrilled animals)	Lampreys (parasites)
	Primæval fish	Sharks
PRIMARY ERA.	Salamander fish	Mud fish
	Gilled amphibia	Axolotl
	Tailed amphibia	Water newts
SECONDARY ERA.	Primæval amniota	Between tailed amphibia and primary mammals
	Primary mammals	Beaked animals
	Pouched animals	Pouched rats
TERTIARY ERA.	Semi-apes	Lori (Stenops), Maki (Lemur)
	Tailed narrow-nosed apes	Nose apes, holy apes
	Tail-less narrow-nosed or men-like apes	Gorilla, chimpanzee, orang, gibbon
	Speechless men or ape-like men	Deaf and dumb, cretins or microcephali
QUATERNARY ERA.	Talking Men	Australians and Papuans.

(*Table after Haeckel.*)

CHAPTER XI.

LOCAL DEVELOPMENTS.*

THE NERVOUS SYSTEM.

IN man and the higher animals the greater part of the animal organs must be referred to the skin-layer (exoderm) and the greater part of the vegetative organs to the intestinal-layer (entoderm). In gastræada the simple skin-layer did actually represent all the animal organs and functions; and the simple intestinal-layer the vegetative organs and functions.

The organs of mental life arise from the external skin-covering. The mind and sense activities were originally situated on the outer surface of the animal body and alone dealt with and received impressions from the outer world, just as may be seen in those rare cases of blindness combined with deafness and dumbness but, under the influence of natural selection, the complex cell masses which had become especially sensitive, gradually withdrew into the shelter of the interior of the body and laid the

* Haeckel.

foundation of a central nervous organ. As differentiation advanced—the distance and a distinction between the external covering and the central organ increased—conductive peripheral nerves became a necessity.

In Protozoa a skin covering is wanting—hence, there is no nervous system. In metazoa or intestinal animals (at first) there is no nervous system; its functions are performed by the exoderm or the simple cell-layer. In zoophytes this simple cell structure is the skin-covering, motor apparatus, and nervous system simultaneously. But in flat worms and turbellaria there is an independent nerve-system, the upper throat ganglion, which is distinct and separate from the outer skin-covering. From this simple rudiment has been developed the complex nervous system.

In Earth-worms the earliest rudiment of a central nervous system is a local thickening of the skin-sensory layer which is afterwards detached from the horny plate. The medullary tube of vertebrates originates similarly.

In the Amphioxus there is only a simple cylindrical cord extended longitudinally through the body; it is a simple tube and above it the notochord or rudimentary vertebral column. Closely examined a small bladder-like swelling at the fore-end may be seen both in this and the ascidian larva and it is the first indication of a brain. This simple central marrow answers to the throat ganglion in lower worms.

In Turbellaria nerve-threads radiate from this ganglion, and the elongation of it gave rise to the medullary tube.

In Articulated animals this ganglion has developed a throat ring along with the ventral marrow. These are found also in the annelida, echinodermata and mollusca. But *only in the vertebrata* has the central marrow developed along the dorsal side; in the other animals it is *ventrally* situated.

In the Cyclostomi the anterior extremity forms a pear-shaped bladder, or brain and cord, and consists of five parts one behind the other, as five bladders.

In the Amniota *only* is there a noticeable curving of the rudimentary brain; it takes place simultaneously with that of the head and neck and curving of the whole body, owing to the upper dorsal surface of the brain growing faster than the ventral surface. In birds and reptiles the mid-brain, central and hind brains develop considerably. But in Mammals the hind-brain is small and covered by fore-brain increase. The five parts of the brain are—

The Fore Brain, which embraces the two hemispheres, olfactory lobules, lateral ventricles, corpora striata, fornix and corpus callosum.

The Twixt Brain.—Optic thalami, third ventricle, pineal body (the remains of a once functional eye in the lower orders of amphibians and reptiles) and infundibulum.

The Mid Brain.—Corpora quadrigemina, aquæ duct of sylvius (iter a tertio ad quartum ventriculum), and cerebral peduncles.

The Hind Brain.—Cerebellum with vermiform process and pons varolii.

The After Brain or the medulla oblongata consists of the pyramids, olivary bodies, corpus restiforme and fourth ventricle.

In the higher mammalia the fore-brain develops exclusively and is found in perfection in the placentalia.

In the lower mammalia the surface of the hemispheres is smooth and even, and the fore-brain does not cover the mid-brain. In a stage higher this is covered. In Apes the fore-brain *covers the hind brain.*

The convolutions and furrows are proportionate with intellectual activities. In the human fœtus the convolutions of the brain are, at the end of the seventh month, in the same stage of development as found in the baboon when adult (Bischoff). Finally, the corpus callosum attains its full development *only* in the placentalia.

The complex nervous system arose, then, out of one portion of the skin-covering, whilst out of the other developed the skin as now seen. The skin consists of two layers, an outer epidermic or horn portion and a softer or true skin portion.

Situated in the skin are glands which began first as plugs of the horny portion penetrating the corium or softer portion in which a canal formed, due to the softening and breaking down of central cells.

The sweat glands are long and coiled but do not branch. The sebaceous glands are branched, also the "tear" glands and those which secrete the cerumen in the ears.

Sudoriparous and sebaceous glands are found only in mammals. "Tear glands" in reptiles, birds and mammals, but not in the lower vertebrates. Hence the satirical expression of "crocodiles' tears" applied to those who freely weep when there is no sympathetic suffering.

Milk glands are enlarged sebaceous glands, which by liquefaction of their contents (fat cells) produce milk. In apes, bats and elephants there are only one pair. Occasionally in the human form there are two or more pairs one behind the other. The famous statue of Diana at Ephesus and of Cybele, also, are represented by many pairs to signify that the earth gives aliment to all living creatures. The milk glands in the male form are also capable of secretion in a few and rare instances.

Since these glands are an inward growth of the epidermis, so hairs and nails are an outward growth; they begin in the same way by a simple conical plug in the outer skin, within this a firmer central cellular mass of conical shape soon forms.

The palms and soles in man, apes and other mammals are bare. Among the higher apes only a thin coat of hair covers certain parts of the body—the face, the breast and inner sides of joints are thinly covered in comparison with the back and outer sides. On the back of the head it is long as in man and the males have much beard and whisker.

In the Indo-Germanic or Semitic race the shoulders, back and outer sides of the limbs are occasionally thickly covered with hair.

Man resembles the elephant, rhinoceros, hippopotamus, whales and other mammals which have partially lost their original coat of hair in consequence of adaptation through sexual selection. General hirsuteness of the body was degraded while the beard and the hair of the head advanced to perfection. Climate and other conditions may have promoted the loss.

On the upper and lower arm the hairs are directed towards the elbow, meeting at an obtuse angle. Except in Man, this only occurs in the gorilla, chimpanzee, orang and some species of gibbons; this peculiarity is explained on the assumption that these animals were accustomed as now during rain to bring their hands over their heads or over a branch overhanging their heads. In other gibbons as in other animals the hairs are directed towards the hands. The nutrient arteries also enter the bones in the same direction.

The Skeleton.

In Man and nearly all other Mammals, whether it be the giraffe or the hedgehog, there are seven cervical vertebræ; twelve or thirteen dorsal vertebræ; five to seven lumbar; and three to five sacral vertebræ together, these latter equal eight to nine or ten. Tail vertebræ, four to thirty-one. Man has four. The Simpai thirty-one.

Tail-less Mammals are Man, the orang, gibbon, gorilla and chimpanzee. The total number of vertebræ in these being thirty-three or thirty-four. *Tailed Mammals* have a total number of thirty-four to sixty including the tail. In both classes the lumbar and sacral vertebræ range from eight to ten. Man has ten.

The main outline of every vertebra is that of a signet ring; the thicker part of which is a short disc of bone called the body, faces the ventral side, placed one upon another they constitute the vertebral column; and the thinner part forms a semi-circular arch towards the back, by the aid of ligaments these arches of the vertebræ form a long canal or protection for the spinal cord. The skull is the anterior section of this vertebral column modified. The amalgamated upper vertebral arches form the arched or dorsal side of the skull. Arches analogous to those enclosing the spinal-marrow develop on the ventral side to protect the thoracic and abdominal viscera. In the lower vertebrates they form a canal enclosing the aorta and the tail vein. In the higher vertebrates most of the inferior vertebral arches are lost. The ribs are large vertebral arches which have become independent. Gill-arches are of similar origin; they are actual skull ribs which originated from the lowermost arches of the skull vertebræ.

The breast bone (sternum) originated from the side halves of the opposite ribs.

The intervertebral substance is elastic and the remains of the notochord which has been more or less compressed by the cartilaginous tissue growing around it to form vertebræ. In birds and reptiles however this is lost.

The skull of the Selachii (sharks) is the only record which affords proof of the vertebral theory of the skull. The gill-arches of these animals show that their primordial skull was formed of a considerable number, at least nine or ten primitive vertebræ; and the brain-nerves which arise from the base of the brain confirm this, for except the first and the second pairs, they are only modified spinal nerves, since they essentially resemble the latter in their peripheric distribution.

Gill-arches. The first pair forms the upper jaw and palate; the lower part of the lower jaw and two ear ossicles.

The second gill-arch forms the third ear ossicle (stapes) with its muscle; styloid process and ligament and the small cornu of the hyoid bone.

The third gill-arch, cartilaginous at the anterior portion, forms the hyoid bone and its great cornu.

The fourth gill-arch is rudimentary in mammalia.

Of the fifth and sixth pairs there is no trace in mammals, but they are permanent in fishes.

Gill-openings are four, and in the human embryo are only interesting as rudimentary organs which soon disappear entirely by concrescence.

The first gill-opening—branchial or pharyngeal fissure—is situated between the first and second gill-arches and becomes the tympanum and eustachian tube. Towards the end of the sixth week the others are closed in the human embryo.

Vertebrates, as regards the structure of their limbs, are portioned into *three* main groups. The most ancient skull-less, and jawless invertebrates have no paired limbs, they are represented by the amphioxus and cyclostomi. In the second group of vertebrates are the two classes of true fishes and dipneusta with two pairs of lateral limbs (fins) pectoral and abdominal. In the third group are amphibia, reptiles, birds and mammals with two pairs of legs, in the form of five-fingered feet.

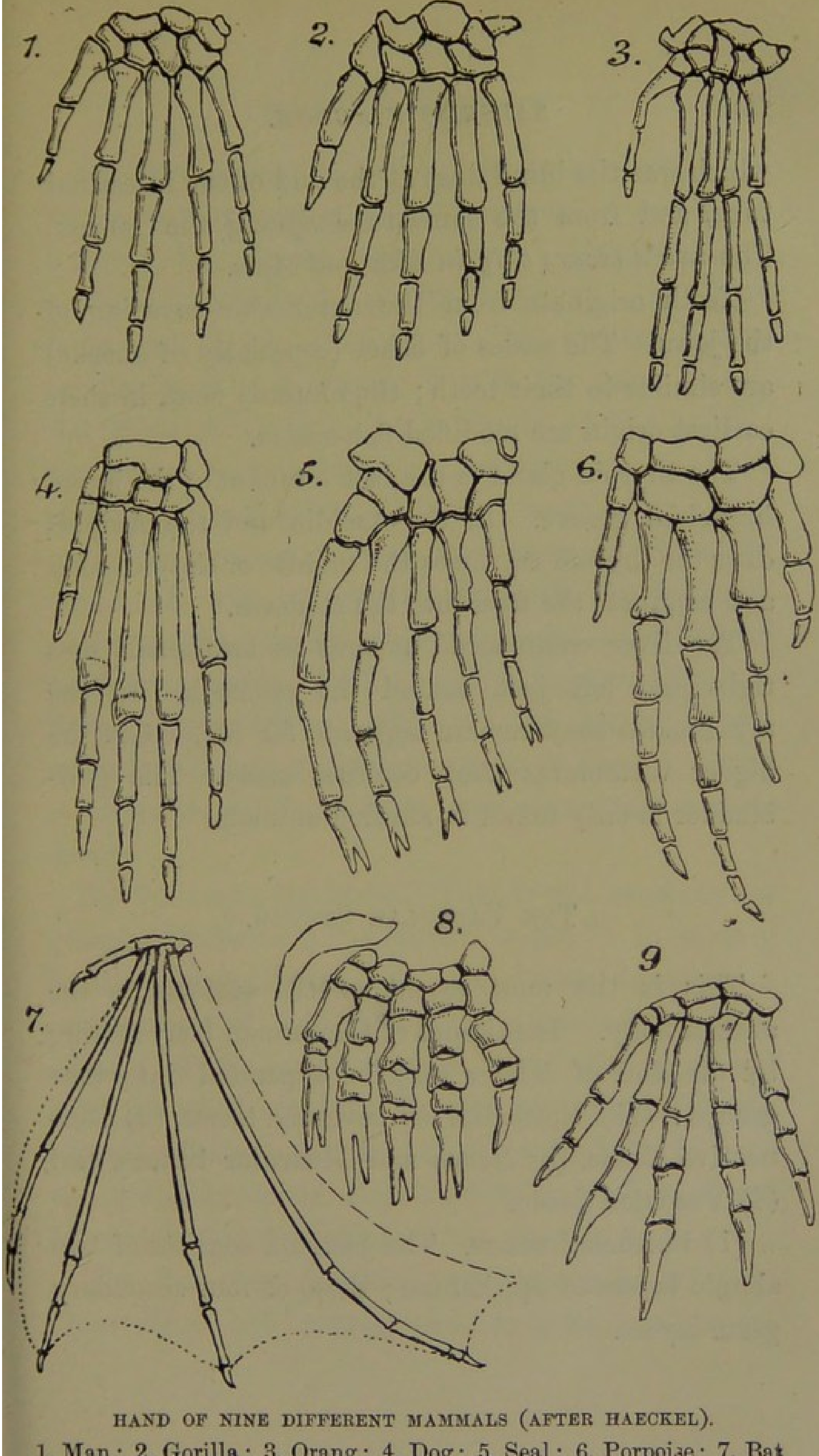
Professor Haeckel has shown in this diagram that while the internal skeleton of the limbs is preserved by *inheritance*, the external form is changed by *adaptation*. The hand or forefoot of nine Mammals is represented in—1, The hand of Man is, in its formation, between that of 2, the Gorilla, and of 3, the Orang; 4, the Dog; 5, the Seal; 6, the Porpoise; 7, the Bat; 8, the Mole; and 9, the Duck-bill. This last is nearer to the common extinct primary form of mammals than any known species. Hence Man in the formation of his hand differs less from this common primary form than do any of the rest.*

The Intestinal System.

This is the oldest system in the body and dates from the Laurentian epoch. As the Synamæbæ developed they engaged in two separate tasks—one half became nutritive cells with a digestive cavity, the other half formed protective covering cells—an inner nutritive or vegetative layer and an outer covering or animal layer.

The lungs arose from the swimming-bladder

* Haeckel.



HAND OF NINE DIFFERENT MAMMALS (AFTER HAECKEL).

1, Man; 2, Gorilla; 3, Orang; 4, Dog; 5, Seal; 6, Porpoise; 7, Bat
8, Mole; 9, Duck-bill.

which was the blind duct at the end of the intestinal tube, and from the same tube sprang the larynx. The *uvula occurs only in Men and Apes.*

Teeth originate from the outer skin-covering of the jaws. The scales of fishes (especially of sharks) are similar to their teeth; thus human teeth in their earliest origin are modified fish-scales.

The thyroid gland is the last remnant of the hypobranchial groove. In the Ascidia and the Amphioxus the thyroid traverses the middle of the gill-body and conducts the food into the stomach.

The liver commenced at first as two small sacs right and left just behind the stomach. In the myxinoides they remain separate for life, but in the higher vertebrates they coalesce early. The gall-bladder is only found in skulled animals.

The Vascular System.

This is the most recent of the systems in the animal body. The tissues of the human body arising by division of labour may be separated into four groups:—(1) Epithelial or covering tissue, (2) Connective tissue, (3) Nerve and Muscular tissues, and (4) Vascular tissue.

(1) Epithelial tissue. The gastrula consists of two simple layers of epithelium; these of four secondary germ-layers.

(2) The connective tissue is an intercellular substance—a connecting and complementary substance between the tissues as an inner supporting and protective covering for the inner organs. Jelly-like, fatty and chorda tissues are the earlier—fibrous cartilaginous and osseous tissues the more recent. All these forms are the products of the middle germ-layer or mesoderm; or more accurately of the skin-fibrous and intestinal-fibrous layer.

(3) The neuro-muscular layer is more recent in origin. In the lowest plant-animals the body, in some, merely consists of epithelium; in others of connective tissue which develops between the two primary germ-layers; while in the higher plant-animals a neuro-musculum tissue is formed which is afterwards differentiated into nerve and muscle tissue.

(4) The vascular layer. This is the most recent group. It forms a "vascular carpet." It is only in the higher worms that this system develops, in consequence of a simple cavity (cœloma), or of a system of connected spaces round the intestinal tube, in which cavities the nutritive fluid (blood), exuded through the intestinal wall, collects. In the scolicidæ blood circulates from back to front. In vertebrates it circulates from front to back.

The skin and intestine are thousands of years older than the nerves and muscles, and these thousands of years older than the kidneys and blood-vessels; and these latter thousands of years older than the skeleton and reproductive systems.

The Excretory System.

The system of excretory ducts known as kidneys is universally diffused throughout the worm tribe even in the lowest class, and appears long before there is any trace of a heart.

In acœlomatous worms, which have no body-cavity, no blood nor vascular system, there is always an excretory system—a pair of branched canals lined by a layer of cells which absorb useless juices from tissues and discharge the effete matters through an external skin-opening. Gliding-worms (Turbellaria), trematode and tape-worms are all provided with these glands, which must be regarded as highly developed pouch-like skin-glands, they are like the sudoriparous glands of mammals, and like them are developed from the skin-sensory layer. In unsegmented worms only a single pair of kidney ducts is present. In the Ringed worms (Annelida) where the body is composed of many segments or metamera a pair of kidneys exists in each segment. To the primary skin aperture an internal secondary opening into the cœloma or body-cavity is added. This opening is provided with vibratory cilia, which aid the passage of the secretional juices in absorption and their discharge from the body. The male and female reproductive cells when mature pass into the cœloma and are carried out of the body with the excretion.

In Myxinoides the primitive kidney is a long tube on each side of the body from which project small horizontal tubes each one terminating in a blind vesicular capsule; this capsule encloses a knot of blood-vessels formed by afferent vessels, which convey arterial blood into, and efferent branches, which convey the blood out of, this glomerulus. In the human embryo *kidneys* are present long *before a heart is discernable.*

CHAPTER XII.

SURPLUS ORGANS.

There is a science of rudimentary, or surplus, organs which in reference to their philosophical consequences may be called Dysteleology or the doctrine of purposelessness.*

In every system of organs in man and vertebrates are found "worthless heirlooms." The scanty hairs on our bodies are useless, and the remains only of the hairy covering of our ancestors. The hair on our arms tends to converge from above and below to a point at the elbow; is common in the gorilla, chimpanzee, orang, some species of hylobates and some few American monkeys. Livingstone says, "The gorilla sits in pelting rain with his hands over his head." The direction of the hair and nutrient arteries of the bones on our own arms is a curious record of our former state. Women in all races are less hairy than men; in some of the quadrumana the under side of the body of the female is less hairy than that of the male. Our male ape-like progenitors acquired

* Haeckel.

beards to charm the opposite sex, whilst the females were denuded of hair as a sexual ornament.* The long whiskers and beard which some men affect, point to a reversion to the ancestral type, particularly when conjoined with facial peculiarities so that these individuals unknown to themselves strikingly illustrate their Simian progenitors.

The ear muscles in man are useless. The ears of the chimpanzee and orang are curiously like those of man, the proper muscles of which are likewise but very slightly developed: these animals are never known to erect their ears. This inability in man and several apes to move the ears is partly compensated by the freedom with which they can move the head and so catch sounds in all directions.†

The nictitating membrane or third eyelid in birds—most useful to them—is useless to man. It is found in some reptiles, amphibians and sharks. Also in monotremes and marsupials and some few of the higher mammals such as the walrus. But in man, the quadrumana and most other mammals it exists only as a cresentic fold of skin at the inner corner of the eye.

Structures resembling those found in the lower animals seem to have existed in the ancient races more than in the modern ones. Near the lower end of the arm bone (humerus) an artery and nerve or

* Darwin. † Ibid.

nerve alone passes through a passage which protects them from muscular pressure. This passage is called the supra-condyloid foramen. It is found in the Lemuridæ, Carnivora and many Marsupials. In Man a small hooked-shaped process of bone one-tenth or three-quarters of an inch long is not infrequently found projecting from the inner surface of the shaft of the arm bone two inches above the internal condyle. It is curved downwards and inwards, and its pointed extremity is connected by a ligament to the internal border just above the condyle. This projection is the analogue of the above-mentioned foramen found in many animals and probably serves for the same purpose in man.

The median nerve and brachial artery in one per cent. have this protection. As it is absent in the higher quadrumana this development is probably a reversion to a very ancient order of anatomy.

There is another perforation in this bone between the condyles. It occurs more constantly in anthropoid apes. In prehistoric man it is found oftener than in those of later origin. Among the bones found in the Cimetière du Sud at Paris it amounts to 4½ per cent; in the Grotto of Ossary (Bronze period) in eight out of thirty-two bones; in the valley of the Lesse (Reindeer period) 30 per cent.; besides other places.

Then again there is Luschka's ganglion continuous with the middle sacral artery found in man at the end of the coccyx. The late Mr. Callender suggested it might have the same relation to the development of the spinal cord as (he endeavoured to prove) the pineal gland and pituitary body have to that of the brain. This ganglion is present in the cat and monkey, but not at the extremity of the tail.

There are also various bones and muscles vestiges of ancestors which were largely developed in them but are out of date and useless to man. The occipito-frontalis muscle is still retained, likewise the platysma myoides—these may be useful in giving expression to man's distinctive features and face, and are largely made use of by the criminal class. The platysma is a skin muscle universal in many mammals and useful for driving off flies.

The vermiform appendix, the rudiment of the lengthened cæcum, is found in all mammals except the ourang-outang. It is of no use in man except to retain or form calcareous products, in size similar to date or cherry stones, which set up inflammation, ulceration, and cause death in this or other ways.

De Graaf has found that the pineal gland is the remains of a once functional eye. During development a portion of the gland is constricted off and appears through an opening in the parietal bones as the "corpus epitheliale;" united with its place of origin by a connective tissue pedicle and bundle of nerve fibres. The clue to this was found in the blind-worm, where the "corpus epitheliale" has a structure resembling the eye of a cephaloped; its sheath containing long cylindrical cells like retinal rods and pigment granules, while there is an embryonic lens and a vitreous space filled with protoplasmic tissue.*

Dr. Hale White has shown that the cervical and semilunar ganglia in Man are degenerate organs, like the pituitary body and pineal gland, but as the scale in animal life is descended they become functionally important, and their value varies directly as the size of the animal. The nerve-cells in children under ten years of age are *mostly* healthy and even beyond that age, but in the elderly they are degenerated. In Man these ganglia present the fewest healthy cells, next in the Monkeys, then in the Carnivora and Ungulates with scarcely any degeneration, and in the remaining lower orders of animals with none at all; and age has no effect in this respect. The conclusion is that a study of human pathology confirms the results to which comparative anatomy, physiology and embryology lead, that in Man the sympathetic fibres have the same function as in lower animals, but that the larger sympathetic ganglia are functionless in the adult human being. Dr. White further says that probably there are other

* See *British Medical Journal*, December, 1886, pp. 1265, 1266.

ganglia, of importance to the lower animals, which are degenerate in Man. Likewise the medullary part of the supra-renal capsule.*

In the vascular system are found the remains of vessels which are no longer of any use. In a recent paper on the medico-legal detection of human blood we find with reference to crystallization of blood the very remarkable occurrence that Monkey's blood acts like human. The blood of the lower animals invariably crystallizes as oxyhæmoglobin only; and as far as known at present the blood of the Monkey is the only exception to this rule, whilst crystals which can be obtained from human blood as invariably consist of reduced hæmoglobin. But the shape of the crystals is different in the two cases—those of Man are invariably rectangular plates, while the crystals obtained from Monkey's blood are for the most part diamond-shaped plates, of which two adjoining sides are longer than the other two.†

Various accessory parts proper to each sex are found in a rudimentary condition in the opposite sex. This is explained by the fact that such organs were gradually acquired by the one sex and then transmitted in a more or less imperfect state to the other. Any still existing androgynous forms are to be found in fishes.

* Guy's Hospital Reports, Vol. XLVI.

† S. M. Copeman, *British Medical Journal*, July 27, 1889.

Long after the progenitors of the whole Mammalian class had ceased to be androgynous, both sexes yielded milk and thus nourished their young. In the case of marsupials both sexes carried their young in marsupial sacks. The males of syngnathous fishes receive the eggs of the females into their abdominal pouches, hatch them and afterwards nourish the young as some believe.

Certain other male fishes hatch the eggs within their mouths or their branchial cavities. Certain male toads wrap round their thighs chaplets of eggs from the females and keep them there till the tadpoles are born. Certain male birds also undertake the whole duty of incubation. And male as well as female pigeons feed their nestlings with a secretion from their crops. Supposing then that male Mammals aided females in nourishing their young, and if from a smaller production young males ceased to give aid, a disuse of the mammary glands would lead to inactivity.* Hence in the present day the nourishment of the young devolves entirely on the females, but this does not excuse husbands from providing for their wives during this eventful period, nor yet up to a much later date.

"The individual higher animal in embryonic development passes through," says Joseph le Conti, "temporary stages which are similar in many

* Darwin.

respects to permanent or mature conditions in some of the lower forms in the same group; for example, a frog in early stage is a fish and would be so classed if it stopped at this stage, but it does not." "The embryo of a higher animal of any group passes *now* through stages represented by lower forms, because in its evolution its ancestors *did actually have these forms.*" It is, as it were, a brief recapitulation of the main points of the family history—the minor points having dropped out.

"The Divine Creator has been represented by Agassiz," says Haeckel, "as an idealized Man, a highly imaginative Architect who is always preparing new building plans and elaborating new species." Moreover, throughout the sacred writings God is constantly described as a Being actuated by passions like man—quite irreconcilable with love, goodness, purity, wisdom and power—hence if these writings are not read according to the spirit and intention of the oriental and poetically minded writers God is degraded to the level of his creation.

"If man had an independent creation the rudimentary organs which have been briefly alluded to would be an incomprehensible enigma." But on the theory of descent from the smaller to the greater all those parts of the body which in the course of centuries have fallen into disuse, yet which in ancestors performed definite functions, are intelligently accounted for.* This view does not detract from the majesty and all-pervading power of an eternal God, nor does it rob him of life-giving power whether in the depths of the ocean or inmost recesses of the earth where work, incapable of being seen by the utmost ingenuity of man, goes on incessantly and orderly, according to immutable laws over which Man has no control, for whether the creation be a Monad or a Man the phenomenon is the same, since man is but an accretion of cells.

And, further, may not the "heirlooms" be regarded as landmarks left for our instruction by which alone we have become able to understand the mystery of the past; and ought we not to rejoice in that beneficent wisdom which has guided our intellects to unravel the secret history of nature, rather than ascribe to an Infinite Being the instantaneous creation of an imperfect finite being, which in the course of ages is only slowly getting rid of anomalous and useless organs? One is the power of majesty, the other the assumption of ignorance.

* Haeckel.

CHAPTER XIII.

ANTIQUITY OF MAN.

For many ages all that was known of the origin of man was derived from the sublime and magnificent description of the creation recorded in the first chapter of Genesis. Some who read this chapter imagine that all things were created instantaneously in the order set down on the several days enumerated; and that man himself on the sixth day sprang into existence without initiatory preparation, as mythology represents Minerva, fully armed, springing out of Jupiter's head after Vulcan's blow. The historian's object, however, was not to describe a miracle but to depict a daily amount of work executed by the Creator, for the purpose he had in view—namely an outline of the growth of the world in six portions of time, to force upon the Israelities the necessity for a portion of repose after toil on six days; and to emphasize this necessity for rest, he represents the Almighty as a Man resting from his labour on the seventh day.

Seven was considered a sacred number; as such its origin has been referred to the seven planets,* the early worship of which was practised by the Egyptians and Semitic nations. The Hebrew word for seven means an oath because oaths were confirmed by the sacrifice of seven victims or seven witnesses or pledges. The same word also has the meaning of plenty, abundance, satiety and fulness. Hence seven may stand for completion or perfection, or a cycle completed begins once more.

In all vital phenomena periods of rest occur—the heart which, to most folks, is considered to be in constant action has, nevertheless, its periods of perfect rest; if it were not so exhaustion would soon set in. In fever when the pulse-beats are increased this want of rest becomes manifested, *i.e.* the periods of repose are shortened. Hence, rest is as necessary for the production of perfection as work is for the production of results.

Moses in the generalization of stupendous phenomena, desired to impress the minds of his followers with this great cardinal fact in the most graphic and solemn way, so he represented the work of creation to have occurred in six days as a precedent for continuous labour by Man and that on the seventh day he should rest—sabbath meaning a cessation from work.

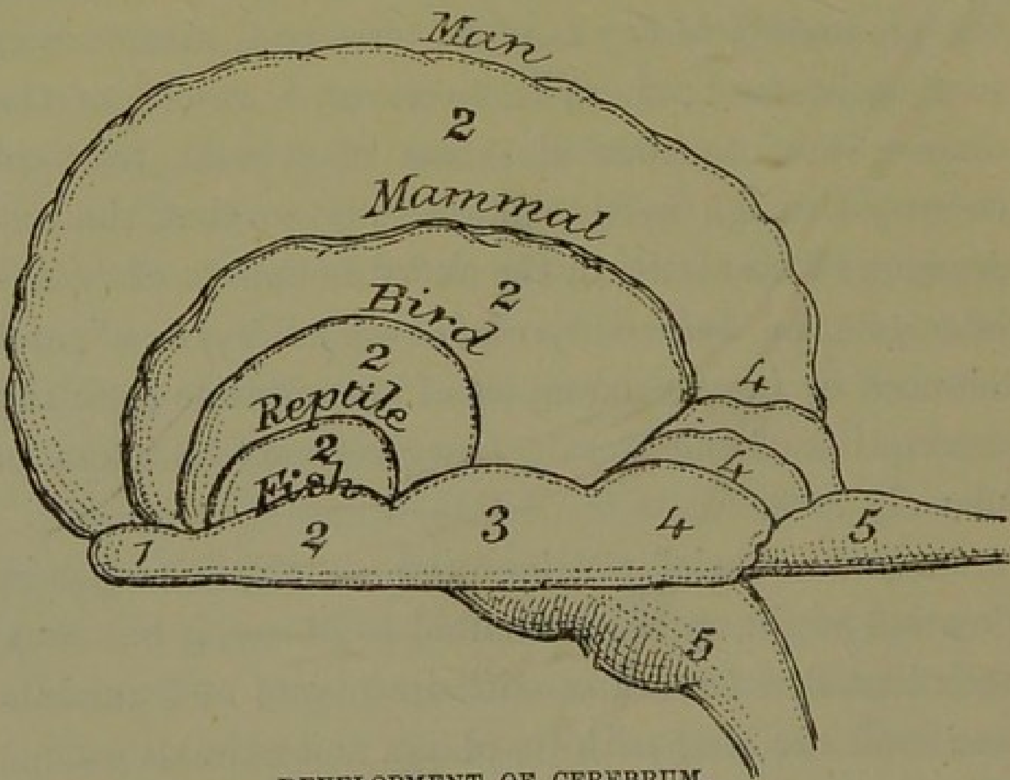
* The seven planets were Saturn, Jupiter, Mars, Venus, Mercury, Sun and the Moon, all which were supposed to revolve round the earth.

In the remainder of the decalogue he lays down commands and moral laws upon the observance of which the safety and happiness of his nation should rest. That which, therefore, is tersely expressed, both in the decalogue and the introductory chapter of Genesis implying instantaneity of action, is due to a philosophical appreciation of mighty phenomena and not to be taken as literally true in detail.

But it has been shown that in the case of light the phénomena might be instantaneous, yet hardly so in the production of dry land as terrestrial structure is now understood; there is, however, a record of the almost instantaneous elevation of a vast tract of country through earthquake agency so that the expressions formulated in Greek by Longinus of "*γενέσθω φῶς, καὶ ἐγένετο· γενέσθω γῆ, καὶ ἐγένετο*" and adduced by him as examples of the sublime from the description of the Mosaic Lawgiver may be taken as literally true.

From the brief outline and description of the creation of the earth, attributed to Moses, it has been seen that first the water with its plants and animals and later the land with its plants and animals gradually developed. Vegetable and animal forms from lowly origin increased in number and size till they assumed gigantic proportions. This was a necessity so long as the earth was enduring more than tropical heat. As intrinsic temperature decreased, the form and size both of plants and animals changed and varied till a race of creatures was produced out of which in the fulness of time eventually proceeded Man.

This gradual progression in activity and intelligence is borne out by recollecting that the brain and spinal cord have a proportional relation to each other. In the Fish it is 2 to 1; in the Reptile 2½ to 1; in the Bird not more than 3 to 1; in the Mammal 4 to 1; and last of all in Man in the proportion of 23 to 1.



DEVELOPMENT OF CEREBRUM.

1, Olfactory lobes; 2, cerebrum and thalamus; 3, optic lobes 4, cerebellum; 5, medulla.

In Reptiles the cerebrum is dominant in place of the optic lobes. In Birds the cerebrum grows large and covers the optic lobes in part. In Marsupials as it is in birds. In Mammals it covers the optic lobes and encroaches upon the cerebellum. In Man it covers all.

There is first a progress of physical development gradually leading up to intellectual activity. And it will be seen from this diagram, also in that on p. 215, that this last has also been progressive. In time this progression may be more fully made out as details are unearthed.

At what precise period Man—as a talking Man—appeared is a matter of conjecture, but the labours of archeologists and geologists have done much in late years to elucidate and extend this knowledge. It seems pretty clear that Man's intellectual activity does not date further back for any historical purpose than the time assigned by Moses to Adam, and that previous to that time his condition may be regarded in much the same light as that in which the inhabitants of the South American continent appear from the account which Darwin has left of them. Naked bodies all bedaubed with black, white and red paint; long hair tangled; mouths that frothed with excitement and expression wild, startled and distrustful. Possessed of hardly any arts, they lived like wild animals on what they could catch; with no government and merciless to every one not of their own tribe. He who has thus seen a savage in his own native land will not feel much shame if forced to believe he descended from humbler animals. A savage delights to torture his enemies and offer up bloody sacrifices, he practises infanticide without remorse, treats his wives like slaves, shows no decency and is haunted by the grossest superstition.

Such we may assume to have been Man's state at the dawn of history, and such it still continues to be in many places; nor is cannibalism extinct in so-called civilized countries—not to mention the fact, brought to public notice by Du Chaillu a quarter of a century ago, and more recently by Stanley. In the Transgariet (South Africa) there were cannibal cave-dwellers so recently as 1850. Even in the west of Ireland about the same period lived a family who for many years waylaid travellers for this disgusting food till they were hunted down. Yet, with all this, there are persons who believe that Man was an instantaneous creation endowed with every noble virtue, and yet has lapsed into the terrible condition in which he is found in many parts of the world at this time, and into which the civilized world will lapse says the preacher if Christianity be withdrawn. But as this condition existed before Christianity was promulgated and the nations in this condition never heard of Christianity it is not easy to appreciate this line of thought.

The cultured nations of antiquity accounted for success or the want of success on the hypothesis of good and evil spirits, as the heathen do at this day. But the thoughtful leaders of the children of Israel, who were content with their own tribal God (El), constantly inveighed against the neglect of the commands which they from time to time enunciated as proceeding from him; and insisted that success belonged alone to Yahveh, whilst misfortune or non-success was due to *some* moral obliquity termed sin, the work of an evil influence called Satan. This is, however, irrational and illogical. It is irrational because it charges the Supreme Good and Creator of the universe with creating a power equal to and opposed to himself. If he, the perfection of goodness, created all things good, by what process of reasoning can he be said to have conceived evil? To say that Satan co-existed is to deny goodness as a Creator. It is illogical, because if Man was created a perfect being why does his body evidence superfluities of structure not necessary for his existence? Was sin the cause of the extinction of the third eye; the production of the appendix vermiformis, and other parts unnecessary and functionless? It has, however, been shown that his body in every stage of development is an improved and higher type of lower animals and the unnecessary parts are "heir-looms," as Haeckel graphically calls them, of his descent. It may be further observed that almost every organism, except the lowest and most imperfect, and especially every highly developed vegetable or animal body, possesses one or more structures which are useless to its organism, valueless for its life purposes and worthless for its functions.* Hence man's apparent degeneration is a want of higher organization, improved education and the exercise of control over animal instincts. The conclusion forced on a sentient mind is how far our religion and morality are removed from goodness and purity in the perfection they should attain, and the importance of keeping ever in front, "The Future is Now."

The history of Mankind is divisible into a Historic and Pre-historic period.

The Historic period embraces what is known of Man during the last six thousand years. The first part of this period is legendary, it comprises the time between the Mosaic account of the Creation and the general use of hieroglyphics, and of cuneiform characters.† This introduction of means for the preservation of events is the true historical epoch and from this time forth as Man's intellectual activity increased and progressed he would seek other materials than clay and stone on which to record his facts. Of these, doubtless, papyrus leaf would beone, and later, skins of animals, though parchment as such was not used before 190 B.C., by Eumenes II., King of Pergamum.

The authorship of the Pentateuch is ascribed to Moses. He was a cultured Israelite, well acquainted

* Haeckel.

† Aboout 3733 B.C. in Egypt, and 3750 in Assyria ("Guide to British Museum").

with the learning and mysteries of the religion both of Egypt and Assyria, as became one brought up in a royal household. As there was literary intercourse between Assyria and Egypt before his time, he may very well have known the traditions inscribed on clay tablets discovered in the mounds of Ancient Nineveh by Mr. Smith, as well as have become acquainted with the information recorded on the clay tablets in the library of Tel-el-Amarna on the eastern bank of the Nile.* The observant and unfortunate sympathy of Moses with his kindred drove him to the land of Midian, where for a long series of years he brooded over the traditions of his ancestors, revolving in his mind how he could best rescue his countrymen and lead them to the land of their origin. For this end he studied the habits, locations and strength of the tribes he sought to overthrow. His own tribe was ignorant and undisciplined in the art of war; he, therefore, made himself acquainted with the tactics and warlike implements of the surrounding tribes, and formulated that magnificent and striking code of moral and sanitary legislation recorded in the Pentateuch. On his return to Egypt, or rather the land of Goshen, his majestic appearance, dignified manner and solemn assurance that he was chosen and sent by their God, Yahveh, impressed the minds of the Israelites; his

* Professor Sayer, in *Newbery House Magazine* for September, 1889.

long absence and its cause, probably, were forgotten ; he was the champion and the leader sent by El, and it was their duty to obey and follow whithersoever he might lead them.

In the prolonged journey of the Israelites through the plains bordering on the land of Canaan it is not likely that Moses had much time to write any large portion of the Pentateuch, and if he did so at all it would be only towards the latter part of that wandering after he had inscribed the decalogue on two tables of stone, and after the construction of the Ark, 1491 B.C. At first, probably, the Law was delivered orally in sections to different classes of Levites, and by them in turn to their successors ; so also, the imperfect details of history recorded in Genesis were thus delivered to other classes. Thus by division of labour the Pentateuch was orally transmitted till eventually, at a later period, it came to be written as the circumstantial narrative we now possess, when moreover the means of writing were more abundant than at the time of the Exodus. Careful as Moses was in his enunciation of the Law, he could not be blind to the fact that oral statements would vary in repetition according to the intellect and culture of the narrator ; hence, as it was important that variations from the text, regarded as of Divine origin,* should not occur, the tribe of

* "The belief that the Lawgiver enjoyed some closer intimacy

Levi was chosen, in which memory was kept under strict discipline with special reference to this task. In consequence of the immense benefit derived from his unremitting care, in framing precepts for future guidance in all matters connected with the religious and social welfare of this unruly tribe, his name was and will for ever be perpetuated as the author of the Pentateuch.

The Prehistoric period embraces all the time anterior to the former; it has been described under three ages, though they run into one another, viz. a Stone age, a Bronze age, and an Iron age, according to the implements found with Man's remains, till lately considered to be comprised within six thousand years. As the science of geology grew and increased it was found that one of these periods must be extended far beyond this limit. In the Mosaic account of creation a Stone age is not alluded to, but at an early date Tubal Cain is described as an artificer in metals, which shows that this Historical

with the Deity than ordinary mortals, pervades the ancient tradition of many nations. Thus Diodorus Siculus (l. 1. c. 94) tells us that the Egyptians believed their laws to have been communicated to Mnevis by Hermes; the Cretans held that Minos received his laws from Zeus; the Lacædemonians, that Lykurgos received his laws from Apollo. According to the Arians, their lawgiver, Zathraustes, had received his laws from the good spirit; according to the Getæ, Zamolxis received his laws from the goddess Hestia; and according to the Jews, Moses received his laws from the God Jao."—Max Muller, "Science of Religion."

epitome of Man upon earth is not a detail of his first and earlier existence, but only of his intellectual beginning as appeared at that time to the historian. But some culture existed at an earlier date, even among Palæolithic men, evidenced by a carving on ivory by Cave-men of a figure of the Mammoth and a group of Reindeer on horns of this animal found at La Madelaine in France.

The Stone age then is divided into two periods, known as Palæolithic and Neolithic, antecedent to six thousand years ago.

Palæolithic deposits are considered to be of Preglacial and Interglacial ages; they do not belong to Postglacial times, for there is no evidence of a warm Postglacial period within the last 80,000 years.

The Stone implements of this period are rude in form and finish, all of flint, and found mixed with the remains of the Lion, Tiger, Elephas Antiquus and other animals which have disappeared locally, or become wholly extinct. This era corresponds to an unknown length of time before the latest period of glaciation, because no change has taken place in the physical features of Europe since that period.

In Mr. Croll's table of eccentricity of the earth's orbit are shown several Glacial and Interglacial, or warm periods. Some of the Glacial periods are of great magnitude; besides these, minor ice-sheets have enveloped Britain at different levels of latitude, shown by surface markings on the Grampians.*

The Glacial period which occurred 240,000 years ago was the last of great magnitude, when the whole of Northern Europe and North America were covered with ice and snow; the glaciers of Switzerland were of gigantic proportions. The glacier of Scandinavia coalesced with that of Scotland and the north east of England upon the floor of the North Sea. The Welsh and Cumbrian Mountains united the Scotch and Irish ice upon the floor of the Irish Channel. Britain and the Isle of Wight were joined to the Continent. Perpetual summer had disappeared and with it the southern Mammalia, to be replaced by Arctic animals and Arctic sterility. As glaciation decreased and the climate became less arctic, great floods from melting ice swept over the low lands of Britain, carrying away Palæolithic implements and animal remains in one confused mass. The south of England was worn by rivers and streams which flowed twenty, forty sixty, and a hundred feet above their present levels, *e.g.* the Solent and the Avon.†

It is then assumed that Palæolithic Man occupied Britain in the Interglacial periods which preceded

* See Professor Geikie's "Geology." During the shortest Glacial era the precession of the equinoxes would complete several revolutions and experience several Glacial periods and several genial climates, each period lasting thousands of years.

† Phillip's "Geology."

the last climax of glacial cold, and the deposition of the great chalky boulder clay of East Anglia, because a recent find of red earth with stone implements, bones and shells under this chalky boulder clay proves that man was an inhabitant of this land before that period.

The implements found in river gravels with Mammalian remains, locally or wholly extinct, are associated with three groups of animals.

Southern.—The Lion, Tiger, Hyæna, two kinds of Elephant, two kinds of Rhinoceros and Hippopotamus.

Northern.—The Glutton, Reindeer, Musk-Sheep, Pouched Marmot, Alpine Hare, Lemming, extinct woolly Rhinoceros and Mammoth.

Temperate.—The Bison, Great Bear, Grizzly Bear, Cave-bear, Irish Elk, Martin, Wild Cat, Ermine, Stoat, Weasel, Cat, Otter, Wild Boar, Horse, Beaver, and others still indigenous to Britain.

The Panther, Fox and Wolf, equally capable of great vicissitudes of climate, are also found with Palæolithic Man.*

The above groups were all denizens of this country when the climate was suitable, and were not merely migratory. It is inferred that the northern and southern groups oscillated to and fro when these islands were joined to the continent.†

Flint implements have been found in many places. In the basin of the River Ouse near Bedford. At

* Phillip's "Geology." † Ibid.

Biddenham, the beds of drift-gravel form a capping to a low hill two miles long by three-quarters of a mile wide. The highest point of gravel is fifty-nine feet above the river, and its surface in the pit, where the implements are found, is forty feet above the river. The gravel rests upon the Cornbrash of the Lower Oolite. Drift deposits are also found in the valleys of the Little Ouse and the Waveney; of the Thames at Acton, Gray's Inn Lane, Reculver, etc.; also in those of the Medway at St. Mary's near Rochester; of the Stour near Canterbury; of the Avon at Fisherton near Salisbury, and near Southampton Water: but they are absent from the north of England and Scotland.*

Palæolithic implements have been found in other places as well as in England: in the valley of the Tiber; in Greece near Megalopolis associated with Pachyderms; in the valley of the Somme near Abbeville in France; and also in Germany, but not in Russia, Scandinavia or the north of Germany. In Piedmont the beds of lignite and river accumulations with remains of the Mastodon, Elephant, Rhinoceros and Hippopotamus are considered by the Italian geologists to belong to an Interglacial age. In Butte County, California, stone mortars have been found in river gravels which were overlaid by a capping of

* See "Ancient Stone Implements," by Dr. J. Evans, F.R.S., F.S.A.; and "Palæolithic Man" (1887), by J. A. Brown.

lava. This layer has been cut through to a depth of two thousand feet by rivers at present flowing. These deposits, therefore, were laid down before the present drainage system was established.

Interesting and instructive as are the remains of human industry found in river gravels with the bones of extinct animals, under circumstances which leave no doubt that they existed together in the same period of time, yet they merely declare that Man was contemporary with these animals; they give no idea of the succession of events in which he lived with animals belonging to Arctic and Tropical climates—the remains commingled were swept together by mighty floods—and that is all. In order then to obtain some notion of the succession of events we must have recourse to a careful analysis of remains found in the caves of Britain and France.

CHAPTER XIV.

KENT'S CAVERN.

THE following description of one of the most famous caves—Kent's Cavern near Torquay—is typical of all other caves where human remains have been found. It must not be forgotten that a vast period of time was required in the formation of a cave, after which the cave was inhabited by animals and human creatures. In the case of Kent's Cavern the succession of events has been clearly made out with immense care and labour by Mr. Pengelley.

The layers in order are as follow :—

1. Blocks of limestone which had fallen from its roof, from a few pounds to upwards of a hundred tons in weight.

2. Beneath and among these blocks a black mould varying from three to twelve inches in thickness.

3. A granular stalagmitic floor, formed by the dripping of water holding in solution carbonate of lime, varying in thickness from three inches to as

many feet, but averaging from sixteen to twenty inches, with blocks of limestone, some of great size.

4. A black band four inches thick of charred wood.

5. Cave-earth of red ochreous loam and large blocks of limestone, similar to those found in the third or stalagmitic floor; also well-rounded pebbles of grit and quartz with a few of slate and granite—all of them such as the hill in which the cavern is situated cannot supply. The average depth was four feet.

6. A second stalagmitic floor, in some places more than three feet thick and in one instance fully twelve feet thick, and eminently crystalline.

7. A brecia of red loam mixed with angular and rounded pebbles, the whole generally found cemented into a concrete of rock-like hardness. It is of unknown depth and differs from the cave-earth in the darker red of the loam and greater prevalence of stones not derivable from the Cavern Hill.

All the deposits occurred in the same vertical section for a considerable distance.

1 and 2. In the Black Mould were found human remains, whetstones, flint flakes, bone pins, bones of sheep, birds, fishes, pig, rabbit and many others with Samian ware; all belonging perhaps to Medieval or Romano-British periods.

3. In the Stalagmite were found charred wood, marine and land shells, bones of the cave-bear, cave-

hyæna, tichorine rhinoceros and mammoth; flint flakes and implements, a human jaw with four teeth, and well-rounded pebbles, beneath twenty inches of stalagmite.

4. The Black Band yielded numerous flint implements and flakes; charred wood, bones partly charred, bone tools, including a well-formed awl, a harpoon or fish spear barbed on one side, a needle with a nicely made eye; the remains of bear, badger, fox, cave-hyæna, rhinoceros, horse, ox and deer.

5. The Cave-earth was very rich in vast numbers of the remains of Cave Mammals of extinct species, the mammoth and cave-bear, and others no longer existing in Britain, as reindeer, wolf and the like; also of species still existing and inhabiting the district as badger, fox and the like. The remains of the Horse, Rhinoceros tichorinus and Cave-hyæna were very abundant. The presence of the Hyæna was further accentuated by remains of gnawed bones and bony fœces in solitary balls, occasionally in considerable heaps. Mixed with these, and to all depths, remains of Man were found; flints of various shapes without polish, a stone hammer, whetstones and implements of bone. A single barbed harpoon was one foot deep in the cave-earth and a double harpoon two feet deep, a bone pin four feet deep in contact with the molar tooth of a young rhinoceros.

6. Below this Cave-earth a Second floor of Stalag-

mite, which contained as many bones as there were in the upper layer, and so far as observed, only of the Cave-bear.

7. The Brecia even surpassed the cave-earth in the number of bones of the Cave-bear buried in it but there was no variety, no trace of Cave-lion or hyæna, mammoth or rhinoceros, no teeth marks, no coprolites. Yet even here were indications of Man, flint flakes of a perfectly angular shape and sharp flint chips, were found three feet deep in the brecia mingled with remains of the Cave-bear.

The facts disclosed above prove that Man was the contemporary of the Mammoth and his compeers; also that he may have been a tenant of this cave at a much earlier period with the Cave-bear.

Kent's Cave occupies "a small wooded limestone hill, on the western side of a valley terminating about half a mile southward on the northern shore of Tor Bay. The hills immediately surrounding the district consist of limestone, greenstone, clay, slate and a reddish grit or compact sandstone." *

Like other caverns in limestone strata the rock was worn away by the erosive action and force of running water condensed into a narrow stream highly charged with carbonic acid gas. The cave is about 230 yards long and has many branches variously named, either from the explorer or some fact that he

* Pengelley on "Literature of Kent's Cavern."

investigated; doubtless also it had many entrances not now discoverable.*

Though the original entrances and exits of water are unknown, yet judging from the appearance of the roof of the "Swallow" and other galleries these passages, during a long period, were tunnels, "completely filled with running water; this is confirmed by the character of the walls in which, however, indications of *corrosion* subsequent to the *erosion* are numerous and well marked." The roof of the cavern is not fissured, and roof drip could only enter by percolation when running water ceased to flow. That the roof of the "Swallow" Gallery "dividing this branch of the cavern from the open day, is of very inconsiderable thickness, is plainly indicated by the levels, as well as by the distinctness with which all external sounds are heard in that chamber; and the series of limestone terraces or steps." It may be surmised, therefore, that one of the entrances for running water was in this direction, but doubtless each separate branch of the cavern had an external entrance, and the large cavern now known, was the result of converging streams.

The materials composing the Brecia found in the cavern are not constituent parts of the Cavern Hill.

* "The Literature of Kent's Cavern," Part V., edited by W. Pengelley, F.R.S., F.G.S., and reprinted from the "Transactions of the Devonshire Association for the Advancement of Science, etc., 1884," p. 189-434.

"Such materials, however, are derivable from loftier adjacent eminences," or possibly from Dartmoor. The bones of the Cave-bear and flint implements found in this Brecia may, therefore, have been washed into the channels at some very remote period and deposited before the cave was habitable by animals.

In "Underhay's" Gallery "there were, in certain places chiefly adjacent to the left wall, remnants of the Crystalline Stalagmite *in situ;* but the greater part of this *older* floor had, as in many other parts of the cavern, been broken up by some natural agency. With rare exceptions, a thin layer of Cave-earth lay at once on the brecia without any stalagmite between them. *In* the Brecia itself, however, there were numerous fragments or blocks of stalagmite which could not but be regarded as remnants of a Floor still older than the Crystalline Stalagmite found *on* the Brecia. Similar indications of this floor, of what may be called the third order of antiquity, had frequently been met with elsewhere in the cavern. . . The Brecia was extremely hard and had to be split out with wedges to the depth of two feet."

The entrances by which water found access for the formation of the cavern and its galleries gradually closed as its approaches became choked and finally blocked with deposit. In this period the Hyæna was not a member of the Fauna of Britain, since no remains of that animal have been found in the Brecia. Moreover, the implements from the brecia were "more rudely formed, more massive, have less symmetry of outline, and were made by operating, not on *flakes* purposely struck off from nodules of flint or chert, as in the case of those from the Cave-earth, but directly on the *nodules* themselves, all of which appear to have been obtained from accumulations of Supracretaceous gravel, such as occur about four miles north-westerly from the cavern. There seems no doubt, then, that the Brecia Men were ruder than those of the Cave-earth; and this is borne out by the fact that whilst the men represented by the less ancient deposit made Bone tools and ornaments . . . nothing of the kind has been found in the Brecia. In short the Stone tools, though both sets were unpolished and coeval with extinct mammals, represent two distinct civilizations." The ruder men, therefore, were the more ancient, for their tools were lodged in a deposit which, whenever the two occurred in the same vertical section, was invariably the undermost and separated by a deposit of Crystalline Stalagmite little if at all short of twelve feet.*

There is no means of hazarding a suggestion as to the length of time Man existed with the Cave-bear in

* "The Literature of Kent's Cavern," Part V., edited by W. Pengelley, F.R.S., F.G.S., and reprinted from the "Transactions of the Devonshire Association for the Advancement of Science, 1884," p. 189–434.

the Brecia period, but a conjecture as to the interval of time which separated the two classes of Palæolithic Man is perhaps permissible. When the Brecia period terminated by the avenues for deposit becoming blocked, the cave was a depository of percolation through the roof; the Brecia was sealed by a crystalline stalagmitic-floor slowly formed, of an average depth of three feet, which in one instance "attained a thickness little, if at all, short of twelve feet."

The accumulation of this deposit would vary and depend upon the rainfall, in dry seasons the drip would probably be *nil*, whilst in wet ones it might be considerable. On the supposition that one-tenth of an inch was formed in one thousand years, we should for twelve feet of Crystalline Stalagmite have a period of 1,440,000 years as the interval between the two civilizations, *i.e.* of the rude and less rude Palæolithic Man. But whilst this deposit was accumulating in the interior, externally denudation was providing for the present opening in the face of the limestone rock.

It has been presumed so far, that this cave was the termination of a water-course whose exit became blocked or hindered by brecia-deposit mixed with stalagmite and lateral percolation. Possibly the cave became filled with water in consequence of its slow exit. The flowing stream unable to pursue its old course through the cave gradually formed a new channel, the deposit brought to the mouth of the avenues remained *in situ* for want of a *vis à fronte* to continue the former movement; the deposit which thus obstructed the old entrances, consolidated and obliterated them as soon as the new channel, or channels were fairly established. The water in the cavern receiving no fresh addition slowly drained away and left the cave dry, except for possible side-percolation and roof-drip, hence Crystalline Stalagmite accumulated during many ages secure, from external floods. Possibly, however, there was still an open entrance, not a water-way, which permitted the entrance of the Cave-bear, for its bones are found *in* the stalagmite.

When the surrounding valleys, which probably did not exist in the Brecia period, began to be formed by denudation of the friable strata overlying and surrounding the more compact limestone, the eroded face of this rock was uncovered and the cave opened to light became on this side subject to inundation.

Cave-earth brought by swollen, muddy torrents poured in at this new entrance and spread over the crystalline stalagmite. At this period the future Vale of Ilsham was on a level with the mouth of the cave, so that this deposit was probably introduced in small quantities at long intervals, since many of the bones and stones in it at every level are invested with films of stalagmite, "showing that the portion of Cave-earth on which they lay was once the surface of the deposit—for the time being the cavern floor." *

This deposit contains the remains of animals inhabiting Arctic and Tropical climates—the Mammoth, Reindeer, Cave-bear and Hyæna—the time occupied in accumulating it must have been considerable, or a period of not less than twenty-one thousand years, *i.e.* the time required for a complete cycle of the equinoxes and probably not more than 100,000 years with a minor Glacial period.

Upon this cave-earth was formed a Black Band of charred wood four inches thick, "in all probability the hearth around which they (men) assembled to enjoy their meals and to prepare their implements for war, fishing, the chase and domestic use." † There is no means for estimating the length of time this deposit took to accumulate. But one fact is certain that the torrent heretofore carried past the cavern's mouth no longer inundated the cave, consequently the present Vale of Ilsham was in progress.

Over this black band was a Granular Stalagmitic floor varying from three inches to three feet but averaging from sixteen to twenty inches. A moderate estimate of time required for the formation of this deposit was not much less than 225,360 years, probably more. The remains of Fauna indicate a

* Pengelley. † Ibid.

succession of arctic and tropical climates, of perhaps several cycles with minor Glacial eras.

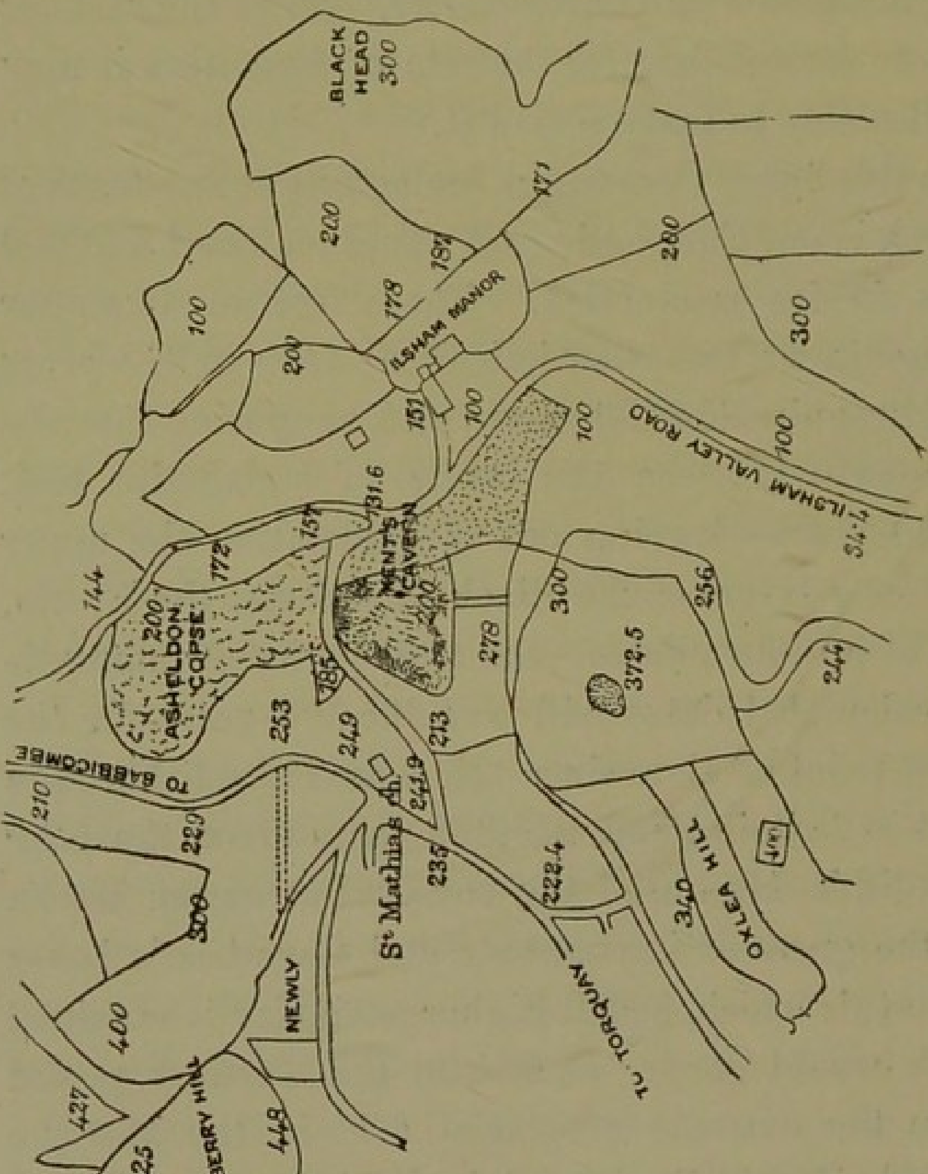
Lastly, there is the layer of Black Mould from three to twelve inches in depth which may have taken from two to twenty thousand years to accumulate.

Referring once more to Mr. Croll's tables, we find that the climate of Britain has in the course of ages become less severe, so that the roof-drip may in later times have been more abundant, owing to the different conditions under which it occurred, and may have produced the quality of stalagmite known as granular. In the Crystalline variety the roof-drip took place in a cavern closed, inaccessible to light and air and in which evaporation would be slow; but in the Granular kind the roof-drip besides being, possibly more abundant, took place in a cavern accessible to light and air where evaporation would be more rapid. Then, again, a further exclusion of light and air was effected by the covering of cave-earth (when the cave was reopened) upon which a layer of stalagmite formed; this produced a certain amount of pressure, yet hardly sufficient to account for the difference of quality in the two kinds of stalagmite. Whether or not this is the explanation of the two varieties, the presumption is that the later stalagmitic layer has been formed more rapidly than the older, because this latter "shows by its thin laminæ that it was formed slowly; and by its great thickness—sometimes fully twelve feet—that in all probability the time over which it extended vastly exceeded that of the *modern granular floor.*"

The rate of formation of the crystalline stalagmite has been taken at one-tenth of an inch in one thousand years. For the rate of formation of the Granular mass I propose to take one-twentieth of an inch in 313 years. In the "Crypt of Dates" inscriptions are extremely numerous; one extends to A.D. 1615. They are "on stalagmite of great thickness and exposed to an abundant drip; and yet two centuries and a half have done no more than to glaze them over with a thin calcareous film, which instead of obliterating, leaves them perfectly legible. At most, the film, in the "Cave of Inscriptions" and the "Crypt of Dates" alike, do not exceed one-twentieth of an inch in thickness." The oldest known inscription is William Petre 1571 in the "Bears' Den." The foregoing extract would imply that since the cutting of the dates the drip has been constant. This may or may not be the case, for an inscription would hardly be cut one-eighth of an inch deep under a still flowing drip; most probably there would be no drip at the time of cutting, hence one-twentieth of an inch would require less time than that stated if the drip were constant. Instead, therefore, of calculating the rate of formation from the date 1615 where a drip is now constant, I venture to reckon from the oldest inscription, A.D. 1571, for the time in which it would take probably to form one-twentieth of an inch. Although "it may be unsafe and therefore unwise to to take the rate as a chronometer," yet in the absence of more correct data for the rate of formation it may be allowable to make use of it.

Twelve feet of Crystalline Stalagmite at one-tenth of an inch in one thousand years would require 1,440,000 years in its production. Three feet of Granular Stalagmite at one-twentieth of an inch in 313 years would require 225,360 years; and, supposing that the Cave-earth between the layers of stalagmite took 21,000 years—leaving out of calculation the upper and lower layers of the Black Mould and the Brecia, both of *unknown* dates—the total period of inferentially calculated dates will be 1,665,300 years for the lowest point of time since the *older* Palæolithic Man dwelt in Britain; and 225,360 years since the *later* Palæolithic Man used the cave. But as the Brecia was the grave of implements and Cave-bear's bones before this epoch, a still higher antiquity is obtained which would go far back into the Tertiary period before the extreme of glacial cold in the Miocene era and relegate the *later* Palæolithic Man to a period anterior to the beginning of the last Glacial era, 250,000 years ago (see page 77).

The Vale of Ilsham may be presumed to commence at St. Matthias' Church 249 feet above the sea level and to pass down by Ashdown Copse on its way to the sea. At present the base of the mouth of the cave is 57·5 feet, says Mr. Pengelley, above a neighbour-



MAP OF NEIGHBOURHOOD OF KENT'S CAVERN,
With the present altitudes. Traced from Ordinance Survey map.

ing "bench mark" 131·6 feet above mean tide level, in the road below and opposite Kent's Hole. Denudation, of one foot of rock occupying 6000 years, will for 117·4 feet require 704,400 years since the valley began to be formed by a small stream. And six feet added, for the height of the cave's mouth, to 57·5 feet, the distance between the "bench mark," and base of the cave's mouth, will indicate the interval of 381,000 years since the cave was opened; and 36,000 years of this time for the deposit of Cave-earth. If, however, the valley was formed by glacier action then this denudation theory is upset and cannot be taken as confirmatory of the length of time occupied in formation of the stalagmite.

The above data are, of course, entirely conjectural; but, as it is only by some such method that an approximate estimate can be formed, it is hoped that in time with more careful and extended researches a better and truer calculation of the time required may be obtained.

At Brixham, not far from Torquay, flint knives have been found under a thickness of thirteen feet of stalagmite. At the rate of one-tenth of an inch in one thousand years we shall have a duration of 1,560,000 years. At one point in the overlying stalagmite was found a Reindeer's horn—in another a Cave-bear's humerus, so that Man in this district preceeded the Cave-bear.*

In the valley of the Meuse Dr. Schmerling of Liege explored various caves. That of Engis contained

* Pengelley.

remains of at least three human skeletons buried under a thick floor of stalagmite; one of the skeletons was embedded by the side of a Mammoth's tooth, when the Meuse probably was fifty feet above its present level; a second skull was found five feet deep in brecia with the tooth of a Rhinoceros, bones of a Reindeer and Horse.

In the cavern of Engihoul, on the opposite side of the River Meuse, human bones were found with those of extinct animals. As gnawed bones and coprolites were not found in these caves the inference is that they were not the dens of wild beasts, but that the inorganic remains found in them may have been swept there by surface-streams and then covered with mud.

In the cavern of La Madelaine, one of the caves of Dordogne, there was found in 1872 the fragment of a Mammoth tusk on which was a rude carving of the animal itself with its long haired mane.*

The foregoing is a summary of the principal points of information at present known concerning Palæolithic Man, and between him and his successor there is a wide interval of time.

When perpetual summer disappeared from the northern hemisphere an Arctic climate prevailed, the Elk, Horse and other Fauna arrived. As the

* See illustration in Lyell's "Antiquity of Man," "Ancient Stone Implements," by J. Evans, F.R.S., D.C.L., and other authors.

climate became temperate these were joined by Neolithic Man, whose implements were not exclusively of flint but of various stones smooth and polished. This occurrence may be presumed to have taken place subsequently to the last period of glaciation, which terminated 80,000 years ago. As years rolled on the sea stole between Britain and the Continent, then Britain was finally separated.*

In Denmark the Stone age corresponded with the growth of the Scotch Fir and partly with the Oak which succeeded it. The age of Bronze corresponded with the forests of Oak, and as these died out they were succeeded in their turn by the Beeches which ushered in the Iron age.

The Peat Mosses of Denmark are from ten to thirty feet in depth. At their lowest levels prostrate trunks of the Scotch Fir, which is not now and never has been in historical times a native of Denmark, lie thickly. At higher levels the Pines disappear and are supplanted by the sessile variety of the common Oak. Still higher the pedunculated variety of the same Oak, now in its turn superseded by the common Beech. At every depth in the peat and under all these various forms of trees, implements and other articles of human workmanship have been found. Weapons of stone are found with the Scotch Fir and Bronze with the Oak.

* Phillip's "Geology."

In lake dwellings stone, bronze and amber * ornaments are found; these latter indicate intercourse with native settlers on the Baltic.

These successive generations of different Flora indicate vast intervals of time for their production, but may be comprised within the period when the climate had become more temperate after the withdrawal of the ice.

* Amber is secreted by trees of the Coniferæ, an extinct genus of Pinites. It is found in Pomerania, East and West Prussia, Lithuania and Poland in separate nodules in sand and clay. Also in Denmark, Sweden, Norway and near Basle. Even in London, Siberia, China and North America. The damara Australis of New Zealand is obtained from Coniferous trees. Damara is also found in Labuan over the coal-beds, as I have seen in that island. But plants of the Coal period are not found in amber forests.

CHAPTER XV.

THE APE AND MAN.

On an earlier page (170), reference was made to the proportion between the brain and spinal cord in the several classes of Vertebrate animals. As it may be assumed that many millions of years were required to bring about this gradual increase of development, so also it cannot be supposed that the present development of brain in the human race was accomplished otherwise than gradually, just as the infant, with a smooth jelly-like brain incapable of intellectual activity, becomes the adult with well marked convolutions and furrows proportionate to surrounding culture and the innate cerebral, or vital, energy of the individual.

The monster growths of Vertebrate animals took place when the temperature of the earth far exceeded the present standard even in the tropics. And, when the Gorilla and his compeers appeared, it may be assumed that the highest type of Mammal was reached. This type arose from a reconstruction of the spinal column and hips, which conferred erect gait upon the hinder pair of limbs, whilst the fore pair were specialized for grasping.* The tail useful for an animal in the horizontal position on four feet, was no longer required, its use being supplied by the freer motion and liberty of the fore limbs not now required for progression. Thus a variety of life and animal existence in a direction different to that which had been customary was inaugurated, but intellectual capacity was absent. The brain of the adult Baboon, probably then as now, was not more developed than is that of the human fœtus at seven months. But with the decline of the extrinsic source of heat, and decrease of the earth's intrinsic temperature, extravagant growths of animal, and also vegetable, bodies ceased; all the organs necessary for carrying on animal life, and the propagation of species by two distinct forms had been secured, and, now, the invigorating effect of a cooler climate was needed to sharpen and consolidate the nervous system of this higher type of animal and to expand the brain.

The lower or simpler in structure plants and animals are, the more permanent are they in form and organization. Plants of a complex floral structure manifest their physical superiority in a greater extent of variation, thus better to secure a succession of race. Longevity of species in the class Mollusca, for ex-

* Haeckel.

ample, exceeds that in the Mammalia—forms which existed far back in the Tertiary era are found still unchanged at the present day—whilst the sensitiveness which exists in Mammalia, from their higher organization, exposes them to every fluctuation in surrounding conditions of temperature and food, and compels them to adapt themselves by variation to new conditions, or else to give place to other types. This is exemplified in the case of the species of animals found with Palæolithic Man and of those found with Man at a later date. There is, therefore, a more frequent extinction of varieties, species and genera in Mammalia, whereby surviving types are limited and the average duration of the same unaltered types is lessened.*

When the erect superseded the horizontal posture in the class Quadrumana, the cephalic extremity underwent alteration and modification. The articulation of the oblong and flattened skull, which was nearly in the same straight line with the spinal column, advanced towards the centre of the bony head-case. By this manœuvre the head was balanced, as it were, on the spinal column at right angles, whilst the spinal cord issued from the skull on a plane inclined at 45°. The increased mobility thus secured to the head allowed it to move through a continuous observing plane of 215° parallel to the

* Haeckel.

ground. The face became shorter by the upper and lower jaws withdrawing towards the skull; this left the nose a distinct but subordinate feature. The upper part of the face, narrowed by approximation of the orbits, secured more central vision.

The quadruped uses eyes and ears as outposts of observation for defence and direction of attack, whilst smell and the sensitive point of the nose aid the powerful jaws in the prehension of food and attack; objects which the laterally-placed eyes fail to bring under notice, the sense of smell and sensitive point of the nose enable the animal to find, for the length of muzzle renders lateral position of the eyes a necessity, as it interferes with the directly downward central vision of both eyes on one point. Place a scrap of food within the visual point of a cat or dog, the animal cannot see it though it knows food is there, he hunts for it not with his eyes but his nose.*

In Man sight is not impeded by a long muzzle, therefore the sense of smell is unnecessary to sight. His outposts of observation are the same as in the quadruped, but his means of attack and defence belong to the arms liberated from use in progression; his height above the ground being increased, his

* Mr. Elliott in his interesting account of "Life among the Todas in Mysore" points out that the hairbreadth escapes from charging Lions and Tigers results from the fact that the individual is within the visual distance of the animal, and not from any amiable or merciful consideration on its part.

range of vision is wider, more accurate and performed without the necessitously rapid movement of the head from side to side observable in the quadruped. These alterations and modifications preceded the growth of the fore-brain; in Baboons prognathism is well marked and the eyeballs are deeply set; but decline of prognathism proceeds *pari passu* with the growth of the fore-brain which widens the forehead and pushes forward the eyeballs. In some races prognathism is still a characteristic, even among ourselves, but the more completely it is absent, the higher is the type of race and individual.

Among Mammalia the brain of Man, except in Elephants and Whales, is bigger, and relatively to bulk and weight, heavier than that of the lower animals; doubtless this has been brought about mainly by alteration in structure aided by decrease of temperature and intercrossing of the varieties of the new departure from the horizontal to the vertical posture.

"Every link in the long chain of Creation does not pass by easy transition into the next. There are necessary chasms, and, as it were, leaps from one creation to another which though not exceptions to the law of continuity are accommodations of it to a new series of being." * Only fourteen species

* Hallam, "Literature of Europe," vol. iv. p. 162, quoted in Lyell's "Antiquity of Man."

of the ape and monkey tribe have as yet been detected in a fossil state, and each of them has usually furnished but a few bones of its skeleton to the osteologist. In the middle Eocene strata in the Swiss Jura the jaw-bone of a monkey allied to the howling species, Mycetes, has been named Cœnopithecus Cemuroides, and, when more of its bones are found, may prove to be the oldest known example of a fossil quadrumanous animal.* Hence as the geological evidence of Apes before the Miocene period is so scanty, it is probable, as Haeckel considers, that Anthropoides originated during the Miocene period, and Talking Men at the beginning of the Quaternary.

There are four varieties of the Ape—the Asiatic Gibbon and Orang, and the African Gorilla and Chimpanzee. In the Asiatic species the head is short or brachycephalic; in the African it is long or dolichocephalic. For shortness the two types may be called round-heads and long-heads. As increase of size is often the result of intercrossing between two varieties; it may be surmised that in remote ages the two types of head observed in mankind have arisen by intercrossing and thus produced two higher classes of animals from which the human race subsequently developed.

Du Chaillu in his travels in Western Africa tells

* Lyell's "Antiquity of Man."

us he met with a variety of Chimpanzee (Troglodytes calvus). It is smaller, milder, more docile, less strong than the Gorilla, and builds a nest or shelter of leaves for itself in the higher branches of trees, like an extended umbrella six to eight feet in diameter. Its head is bald, shining black, temper not fierce. The young are white whilst those of the Gorilla are black, and the young of the Chimpanzee (Troglodytes niger) yellow. The head is nearly round and bullet formed,* nose very flat; ears larger than the Gorilla. Eyes sunken—teeth compared with Gorilla small. Hands long and slender, foot shorter than hand. Its mode of progression is known to be on all fours from the callosities found on the backs of the fingers. The hair is rusty black; and the male is larger than the female.

He also describes another Ape under the name of Kooloo Kamba.† It is distinguished by the cry "Kooloo." Kamba, means to speak. It bears a closer general resemblance to Man than any other known Ape. It is very rare. It is smaller than the adult male Gorilla but stouter than the female Gorilla. The head is like that of an Esquimaux or Chinaman.‡ Its face is black and bare. Forehead higher than any other Ape. Cranial capacity pro-

* See illustration in Du Chaillu's "Exploration and Adventures in Equatorial Africa," second edition, p. 360, and plates opposite pp. 371–373.

† Ibid. ‡ Ibid.

portional to size, twenty-five cubic inches. Eyes wide apart, more flat. Ridge over the eyes well marked, muzzle less prominent and broader than in other Apes. The sides of its face are straight, the hair meets under the chin like human whiskers. The arms reach below the knee. The hair on the arms meets at the elbow, its direction is upwards on the ulna, downwards on the humerus—that is, the hairs point in the direction of the nutrient arteries supplying the bones. The body is hairy, the shoulders are broad and the hands are long and narrow; it is a tree climber and the arms and hands are muscular. The abdomen is prominent as in the Gorilla. The ears are large and more like human ears than any other Apes. The jaws are not very prominent. The structure of the head is like that of Man. He further remarks that the Chimpanzee (Troglodytes niger), is a tree climber, does not attack man and the young are tractable, whilst the Gorilla is the reverse and builds no shelter for itself. The Gorilla in fact from his description is a fearfully savage brute whose voice is louder than the Lion's roar; he beats on his drum-sounding chest as he advances to attack, not unlike the way of some savages at the present time.

In the above descriptions we have the nearest living approach to the human form known among the lower animals.

From the facts detailed we can form no estimate of the length of time since the types suggested first appeared. It is impossible to calculate the rate of development, for the duration of time, since the beginning of the Eocene period, may be anywhere between fifteen millions and three millions of years; we are, therefore, at present incapable of fixing the date of the Miocene period.

The examination of the cubical capacity of the skulls of various nations does not afford any clue, because the comparison of ancient skulls with modern skulls is for the same race shifting and inexact—still the examination is suggestive.

As it may be of some interest to have whatever information can be had on the subject, the following table has been compiled from the Crania Theosaurus, Crania Britannica, Crania Egyptica and Crania Americana.

The cubic capacity of the skull and the weight of the brain of various nations are compared with that of Apes in the following table :—

	Race.	Cubic inches.	Highest and Lowest.	Weight in ounces.
	Orang	26	... — ...	14·24
	Chimpanzee	27·5	... — ...	15·10
	Gorilla (largest)	34·5	... — ...	18·91
	Ditto, average of 13 adults	28·85	... — ...	17·36
1	Newly-born Male (English)	20·14	... — ...	11·67
	Newly-born Female (English)	17·36	... — ...	10
	Neanderthal	63	... — ...	32·91

Race.	Cubic inches.	Highest and Lowest.	Weight in ounces.
Negro from Philæ	73	... — ...	38·93
Ancient Peruvian	73·2	81·5 and 65·5	39
Neanderthal (Huxley probably)	75	... — ...	40·13
5 Modern Peruvian	76·8	... — ...	41·22
Ancient Negroid	79	88 and 71	42·54
Ancient Mexican	79	... — ...	42·54
Flatheads of Columbia race	79·25	... — ...	42·69
Modern Peru, Bagota, Mexico	79·6	... — ...	42·9
Ancient Egyptian	80	96 and 68	43·15
Australian	81·7	102 and 71	44·16
Ancient Semitic	82	88 and 69	44·35
American, barbarous tribes	82·4	... — ...	44·59
Asiatic Bengalees, Aryas	84·4	100 and 65·6	45·79
African Negroes	85	... — ...	46·15
African Arabs and Negroes	86·2	105 and 66·8	46·87
2 *Ancient Pelasgi*	88	97 and 74	47·38
4 American Esquimaux, Caribs, etc.	89	... — ...	48·57
Oceanic	89·7	... — ...	48·98
Irish	91	108 and 77·8	49·76
6 Caucasian, A.D. 614 ...	91·8	... — ...	50·25
Esquimaux...	92·9	... — ...	50·9
Chinese	92·9	... — ...	50·9
Ancient Briton	93·15	Male, 112·58 and 80·3 Female, 88·77 and 77·83	51
3 Modern Caucasian ...	94	112 and 79	51·57
True Fins	96·3	... — ...	52·95

NOTES TO TABLE.

1. The brain attains its maximum size in from three to eight years. Increases in weight up to twenty-five or forty years. Dwindles after sixty.

2. The largest heads are found in the Pelasgic group, so called from the Pelasgi (a word signifying old or ancient; they were Aryans mingled with Semitic races), a people of Greece, supposed

to be the most ancient in the world, who peopled the Nile valley and Nubia; also gave origin to the Etruscans. Found in Memphis, Thebes and Abydos. The Semitic or Hebrew type and Egyptian type are not appreciably different from the Arab and Hindoo. The Negroid is an admixture of one or other of these types with the Negro found also at Maabdêh. The Egyptian also at Ombas and Debad besides the places mentioned above.

3. Includes Swedes, Germans, English, Prussians and Anglo-Americans.

4. Includes Esquimaux, Caribs, Araucarians and Chemesyans.

5. The Peruvians have the smallest heads, the Mexicans something larger and the barbarous tribes the largest of all, 82·4 cubic inches.

6. A collection of it is said 10,000 skulls at the monastery of Mar Saba between Jerusalem and the Dead Sea, in consequence of a massacre of early Christian monks, Ancient Caucasians, Greeks and Romans, A.D. 614. See an article by Dr. Dight in the *Journal of American Association* for February, 1887.

The brain weight has been calculated from the mean cubical capacity of the race represented, by the formula given in Crania Britannica,* and the cerebral matter of the Ape has been taken as of the same specific gravity as that of the human brain.

The cubic capacities in the above list are the mean of the skulls of both males and females, assuming them to be those of the upper classes with a "greater command of the material comforts of life

* The cubical capacity of a skull multiplied by the specific gravity of cerebral substances taken as 1·040 and divided by 1728, the number of cubic inches in a cubic foot of water, will give the weight of brain matter, from which five ounces must be deducted for the weight of the containing membranes and fluid contents, *e.g.*

$$\frac{93{\cdot}15 \times 1{\cdot}040}{1728} = x \text{ oz.} - 5 \text{ oz.} = 51 \text{ oz.}$$

and the necessity which a wild tribe under a severe struggle for existence had for putting itself under the guidance of the ablest men it could find." * The brain of the male is about ten per cent. heavier than that of the female; hence the mean which has been taken may be considered a fair average capacity for the race or tribes, which it would not be were the average of the largest male skulls alone taken. The greater weight of the male brain is not merely in relation to greater bulk and stature but it is actually heavier, for in stature the female is only eight per cent. less than the male.

From the above table it is evident that in 2300 B.C. the Caucasian race was as now the predominant race of the world, for the skull has a larger cubic capacity than any other skull excepting the Fins, Chinese and Esquimaux, who belong to the Mongols or second dominant variety of the human race.

At first sight comparing the Caucasian skull of A.D. 614 with the modern Caucasian skull it might appear that the difference of 2·2 cubic inches in capacity would be a rate for calculation; but as the climate is sub-tropical, does the same race inhabit that district of Palestine now that did so A.D. 614—and if so what is the cubical capacity of this skull? These data are not supplied by Dr. Dight, hence no comparison can be made.

* Rolleston in Greenwell's "Barrow Diggings."

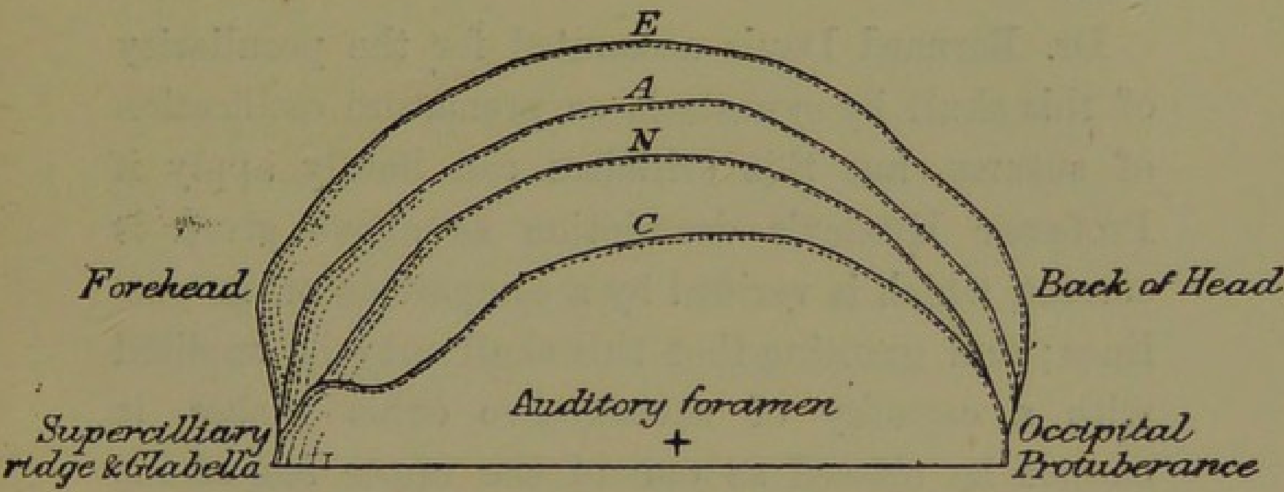
The modern Peruvians, so far as Dr. Morton's description goes, seem to be the descendants of the ancient race, for he found but little difference between them, though the figures recorded seem to indicate a difference. The only possible comparison which can be drawn from this list is that between the ancient Briton and modern Caucasian. Supposing that the skulls of the ancient Britons have been buried for five thousand years, the modern skull presents an increase of 0·85 cubic inches over the older. This is probably a fair estimate; the difficulty consists in knowing the exact period of sepulture of the Briton, for the highest and lowest capacity in cubical inches of the ancient and modern race is very nearly the same, and the geographical position and climate are much the same. The difference between the modern Caucasian skull and that of the Chimpanzee is 66·5 cubic inches. This at the above rate of increase will give 391,176 years. But as it is possible that Man existed as far back as 1,665,300 years in this island the above calculated increase is untenable.

If the human brain falls below 30 ounces in weight, or the skull is less than 55 cubic inches in capacity, it is incompatible with intellectual power and activity; and though a large brain-weight and cubic capacity are generally considered to indicate an increased intellectual capacity yet this is not invariably so, for Dr. Tuke has recorded the brain of an idiot aged 37 with a cranial capacity of 110 cubic inches and a weight of 60 ounces. But, on the whole, increased cubic capacity and great brain-weight are in favour of increased intellectual vigour. And as the Caucasian has the largest brain-weight and capacity of all races at the present time, so is it the dominant form of mankind which probably will ultimately supplant all other races. Yet on the other hand as terrestrial heat decreases and solar heat diminishes, the inhabitants of the tropics may ultimately increase in intellectual vigour and equal the European who may through rigour of climate then assume the proportion and stunted growth of the Esquimaux.

"We must never lose sight of the fact that in dealing with a series of skulls from these Prehistoric barrows we are all but certainly dealing with the skulls of a set of individuals from the upper classes in times when members of these classes were, as are the chiefs of many modern savage races, from the operation of one or both of two causes, larger and more powerful, and *pro tanto* larger brained men than were the mass of the population. In dealing with a series of modern skulls we are not so dealing with the skulls of the upper classes only but ordinarily just the reverse." * The above remark of Professor Rolleston applies equally to those skulls

* Rolleston in Greenwell's "Barrow Diggings."

discovered in the tombs at Thebes, Memphis, mounds and caves in Mexico, Peru and elsewhere. Increased development in the modern Negro may have arisen from intercrossing, so that it would not be safe to compare these skulls with the one ancient Negro recorded, for the effect of intercrossing may be noted in the ancient Negroid.



SIDE ELEVATION OF FOUR SKULLS, AFTER LYELL.
E, European; *A*, Australian; *N*, Neanderthal; *C*, Chimpanzee.

The above diagram shows the difference of skull-case curve between the European and Chimpanzee.

The oldest specimen of human skull known is the Neanderthal from a cave in that part of the valley of the Düssel near Düsseldorf called Neanderthal—a deep narrow ravine seventy miles north-east of the region of the Liege caverns.

Professor Huxley has estimated the capacity of the cast of the portion submitted to him at sixty-three inches, but that probably the whole cubic capacity may have been seventy-five cubic inches. That is, in place of a brain weight of only 32·91 ounces, there would be a weight of 40·13 ounces. This skull is admitted to be the most brutal of all known human skulls and resembles that of the Ape in the prodigious superciliary prominences and forward extension of the orbits with a depressed brain-case.

Dr. Barnard Davis accounted for the peculiarity of this skull by synostasis or premature ossification of sutures, but this criticism can hardly apply if Professor Huxley's description as above given is correct, which is verified by a comparison of the outlines; and granting that this skull may be credited with a capacity of seventy-five cubic inches, it cannot be classed as one of the upper ten of his tribe for there was no trace of care bestowed on the place of its sepulture.

For all practical purposes it may be taken for granted that the human cranium of to-day is much the same as it was five thousand years ago; that probably it has reached its limit of development; and that Man in future will not materially differ from the present type, except perhaps that his body may exhibit fewer traces of his ancestral origin till at last all trace is obliterated. But by the time this consummation is attained, life on earth may have terminated from a deficient food supply for increased population; or from the decrease of intrinsic and extrinsic heat; or through the onward course of the solar system, this earth may have come into contact with some dark body of another system of equal magnitude moving at an equal rate, when collision would at once terminate its career.

CHAPTER XVI.

PASSIONS AND INTELLECT.

THE complex nervous system arose (see Chap. XI.) out of the involution of one portion of the external covering of the animal, and the skin as now seen, from another portion. There is, therefore, an intimate relationship between the external investment of the body and the central controlling power of the whole being.

The Brain of an Infant at seven months of age is as far advanced as is the brain of an adult Baboon; hence at birth the former is two months in advance of the latter at mature age. Nevertheless, at birth the smooth, gelatinous brain of the Infant is totally incapable of the inception or reception of any mental power. The only sense present is that of sensitiveness to external circumstances—on a par with that of the lower animals—if pinched it writhes like a worm, but, owing to the possession of a larynx and nervous centres for co-ordinating muscular movements, it also utters a cry. It has eyes but it sees not, the vacant stare of the newly born evidences cerebral blindness. It has ears but, from cerebral deafness, it hears not; that is, the organs of sight and hearing are present but the nerve-cells do not respond to the stimuli of light and sound. The only sense through which it can be educated is that of sensation residing in the skin.

The very instructive case of Laura Bridgman, who died on the 24th of May, 1889, aged 60, at the South Boston Asylum, is an example of the use that can be made of only one means of communication with the outer world. She was deaf, dumb, and blind from her second year, caused by scarlet-fever. She was, however, taught through the sense of touch to read and write; and made considerable progress in arithmetic and algebra, geography and history.*

Here was a human being, at a very early age suddenly cut off from knowledge of the outer world, again placed in the position of an animal at birth. Her instinct would be retention of whatever she laid hold of for the purpose of satisfying natural animal wants; according to her strength so would she endeavour to overcome power which tended to deprive her of what she had clutched. Had no attempt been made to cultivate the increase of brain matter she possessed, when grown to maturity, she would have been in the condition of many savage tribes at this day who have the apparatus necessary

* *British Medical Journal*, June 22, 1889.

for the reception of culture, but not the knowledge to set it going.

The difference then between Human beings and the lower order of Mammalia is, that one has apparatus, the other has none. Hence, those who have apparatus and cannot use, or have no opportunity for applying, the means or spring of action, are on a par with those which have not the apparatus or organs and to whom the means would be of no use.

Animals are taught by the rod acting through the skin. In time after frequent repetition they learn to connect cause and effect and acquire a knowledge of reward and punishment; this is introspection, or reasoning power of a very limited nature—a power acquired gradually through the outer covering, which can be pushed only as far as the brain is developed. This power arises from instinct, unreasoned prompting or propensity improvable by education.

The only duty an animal feels or knows is to itself, for each one is self-dependent. If an animal is incapable of obtaining its living it is left to die or, if there is a scarcity of food, eaten by its neighbours. The same obtains in the uncultured or lower orders of mankind. The state of living is by violence—strength is life and health, weakness is disease and death. Such is the struggle for existence.

Up to a certain point men and animals are alike in possession of the same propensities which are purely selfish or animal, older than intellect, and dominating the animal world.

Suppose a Cat led by the instinct of hunger or thirst desires meat or milk; she pounces upon a bit of meat or dips her head into a bowl of milk; on discovery she is taught through her skin to wait till one or the other be given to her. Made acquainted with punishment she becomes cunning and adopts another course; she purrs loudly, mews plaintively, wags her tail, paws gently and rubs her body against your legs; by this insinuation or coaxing she obtains the coveted object. She has now obtained knowledge and learned patience, or the means of gaining reward. Her show of affection is ruled by bodily appetite and belongs to no higher mental quality, for she fawns on the object which can supply or gratify her wants, but on the slightest provocation, immediately afterwards will spit, bite or scratch her benefactor.

This is the condition of the majority of mankind in whom the higher developmental increase of brain is uneducated, and who are only capable of understanding the letter of the law. This the early Biblical writers fully understood.

"Train up a child," said Solomon—not one child but every child—"in the way he should go: and when he is old, he will not depart from it."

In a community of creatures of different physical powers might is right, that is slaughter or violence rules the roost, but in a community of creatures of similar physical power stratagem is employed—the coveted object is appropriated and hidden. So it is with mankind; thieving and lying are animal propensities well illustrated in that beautiful allegory of Adam and Eve.

This allegory, drawn by a master hand, represents the beginning of moral obliquity, as applicable now as in earlier ages of the world. Thus Eve allowed inordinate desire to overcome her obedience—through an insinuating, caressing influence, or specious representation of evil for good in the form of a serpent—she stole an apple; Adam affected ignorance of the circumstance, and when prevarication did not help him out of his difficulty, he assumed independence and boldly took to slander, a polished form of robbery not unknown even in those early times, as a justification for his conduct.

> "Ingrate, he had of me
> All he could have; I made him just and right,
> Sufficient to have stood, though free to fall." *

This condition of purity is the inheritance of children till trained otherwise; hence children rightly trained should be angels to all adults; and, for those who can reason, so are our domestic animals, but it is not necessary to worship these as the Egyptians did their Cats.

* "Paradise Lost," Book III.

Thieving and lying, therefore, primary animal propensities, are in mankind the first departures from purity; as we educate ourselves, or allow children to lapse into these acts, so do we or they progress in cupidity and envy. Hatred and murder soon follow as shown in the further allegory of Cain and Abel.

The logical sequence of the decalogue, like that of the first chapter of Genesis, is from the Greater to the less; we there find, first the relation of finite beings to the Infinite, and secondly the relation of finite beings to one another. In illustration of this latter duty, is given the closest relationship which can exist between two such beings: then follows the highest form of injury, murder; next the offence against chastity and then that of theft—these three are but grades of the same injury. After this lying and covetousness, minor grades of immorality, which lead up to theft.

Self-preservation begets desire to obtain whatever will be of advantage to the well-being of the body—legitimate so long as ordinary craving is satisfied and obtained without force, violence, or fraud, *i.e.* an artifice by which the right or interest of another is injured; but illegitimate when the above conditions are disregarded. Temptation is an enticement to evil as opposed to good. Temptation * enters or

* Temptation regarded as an equivalent for Satan or devil, is an intelligible factor in the affairs of the world, but under the name of

comes to the intellect as a suggestion by sight, by hearing or by sensation; it is an animal propensity

Satan regarded as a spiritual power, unintelligible (except so far that we may not always be instantaneously cognizant of a source of thought or action which on reflection we should be; now it is just as essential to be on the *qui vive* for impulses of mental energy as we are for impulses of physical energy, and to say the devil prompted us, is to wriggle out of responsibility and lay the want of education and self-control on an unseen power which may not exist) and it is questionable how far we are justified in reprobating those who worship spirits of evil (as we understand them) because they know not our way of thinking, for they have a perfect right to compose or comfort their minds in their own way for the ultimate issue of their deeds we know not, and it does not rest with us.

The truths in the Bible must be regarded as the productions of Oriental reverence, poetically and gracefully placed before us with pathos, sublimity in many cases, and persuasive simplicity; denunciation is of course equally forcible in a contrary vein. If the Bible is read and studied in this way it becomes a harmonious whole, reflecting the pious and moral beliefs of the times of the writers and worthy of acceptance by all educated intellects; but if read in a prosaic, literal and narrow spirit without regard to the Oriental mode of representing mental images it loses very much of its value for spiritual improvement.

In the account of the temptation or ascribed Satanic influence in the Gospels this poetical mode is adopted, and suitably to one who was to be our example and Saviour; it is the very height of idealization, for it could not be supposed to be literally true. What the physical condition of the Divine person was to whom it refers cannot be entered into. The lesson to be learnt is, that under no circumstances whatever are we to give way to temptation by which we may be led into evil, and all extravagance of imagination is to be controlled, *i.e.* we are to exercise the same control over thoughts as the law has commanded over actions. This view of temptation is borne out in the terms of the Lord's prayer which are, "Lead us not into temptation, but deliver us from evil." The words in the original represent no other meaning than those in the translation, so that if a power of evil meaning an Entity as opposed to God had been intended, other words would have been followed with no regard to intellect. The possession of intellect implies the faculty of seeing and knowing the relations of objects in themselves and their relation one to another. Good and evil are terms applicable to the possession of intellect. Creatures that have no intellect commit no evil as opposed to good. Hence, a human being who possesses intellect is constantly a judge between good and evil. If, then, he will not observe the relations of suggestions, however brought about, but blindly, purposely blindly, follows inordinate desire he becomes covetous; and covetousness if persisted in is reckless of consequences. Temptation, therefore, may be defined as inordinate desire reckless of consequences; or in better words "Every man is tempted, when he is drawn away by his own lust, and enticed. Then when lust hath conceived, it bringeth forth Sin: and Sin, when it is finished, bringeth forth death." * That is annihilation.

This code in its philosophical conception and logical argument is still the foundation of all religious and moral sense. It is by no means out of date as some would have us suppose, but very much to the

used. But this is not the case, consequently dependence upon God, charity to our neighbours and an earnest avoidance of temptation will deliver us from evil, since all things depend upon God. Satan as an Entity has no foundation. But vain imaginings are human.

* James i. 14, 15.

purpose in keeping before children and grown people the impropriety of charging an Infinite or Eternal Creator with being the cause of their backsliding and with being the co-partner of Evil.

The increase of size in the human brain implies not only additional cerebral matter, but a development in a direction different from that which is required merely for movement and sustenance of the body. This increase, arises from expansion of the cerebral hemispheres which completely overlap the basal ganglia and, gives the characteristic appearance presented in the human race. It might be described as a peripheral cephalic expansion of these ganglia with a higher differentiation of the component parts (grey and white matter) for the purpose of increased cognizance. There is, therefore, a central cerebral mass with peripheral nerves (motor and sensory) issuing from the caudal side, for the movement and sustentation of the body, and an anterior cephalic expansion of great complexity contained above and within the bony case, for the lodgment of enlarged faculties embraced in the word intellect; though this expansion may be functionally in abeyance it is nevertheless present. It proclaims Man's superiority over the brute creation wherein may dwell a faculty by which he sees and understands the relationship of one thing to another—a power by which the animal propensities originating in the basal ganglia and occupying a small portion of the cerebrum, may be subjected to criticism and made subservient to his well-being. When this expansion first takes on its functions then intellect asserts its sway. It is introspective in the fullest sense and is made up of more than one combination —the greater number of combinations a brain is capable of, the greater is the intellect. Animals are presumed to have ability for only two ideas on one subject, that is cause and effect or one combination. Hence reasoning in Man, except from defective quality of brain or defective employment, is illimitable, but in the lower animals limited.

When the exercise of intellect begins, will depend upon the integrity and expansion of the fore-brain. The cultivation of intelligence should begin from birth; first the infant is taught control by check on its animal propensities, through an orderly observance of the times of washing, nursing, exercise and rest. Next ideas are presented through the eye and ear. Objects and sounds become familiar, but very frequent repetition of sights and sounds is required before the separate nerve cells become sufficiently sensitive to be thrown into instantaneous vibration to call up and present images rapidly on requisition. For example, a dog or cat will require very frequent repetition of the name by which it is to be called; it is usually accompanied by the offer of a bribe in the shape of meat or milk, till at last the animal on hearing the familiar sound connected with its stomach, obeys instinctively.

In a similar way Infants learn to connect sound and sight; one helps the other, and long before the child can speak he has a good store of substances or images at disposal which he learns to combine so as to understand what is said. As speech comes to him he improves his knowledge, and here his superiority over the inferior creation is manifested—these latter understand to a limited extent, but cannot progress—there is no surplus store of cerebral matter to advance upon—a blind alley is the result.

Human beings who never exercise their intellects, after a time lose the power to do so; they are what is termed stupid, dolts, and so forth. This is apparent when the powers of life fail; fresh ideas cannot be grasped, the intellect falls back on those sounds and ideas which are the oldest and of which the nerve cells are most retentive and sensitive; the most recent acquisitions are lost, the oldest alone retained; at last even these are lost and the human being once more becomes a mere animal.

Intellectual propensities like animal ones are progressively formative and, as the powers of life fail, progressively decay. If the intellect has been used for the object of heightening the animal propensities, an intelligent beast is the result, that is, a creature which follows instinct inordinately. But if the animal propensities have been held in check or controlled and used merely for legitimate welfare, we have the true type of superiority, a useful member of society in the subjugation of self.

From this will follow a code of morality. Thieving and lying, which are our natural propensities, will be deemed immoral when practised as a portion of education, because they increase selfishness, are at war with society, degrade character and do not lead to the higher condition of good to our neighbour. Hence what is perfectly natural for an animal without the capacity for advance in intellect, is a moral dereliction where superior intellect is present or should be present.

Reason then and not violence is the guiding-star of superiority. It has taken millions of individuals to bring it to perfection as a cultivated art, and has to be instilled into every new-born babe. Each one, however humble his station in life, can help to improve his successors, directly through his children, indirectly through his example; hence the value of actions mirrored in descendants, and those performed under a cloudless sky, are pictured for ever—to be read in the one case by the progeny, in the other by the omnipotent Supreme Ruler of the Universe.

The first example in literature of this higher nature is the instructive and interesting history of Joseph.

From his early youth a higher nature is exhibited; there is no trace of selfishness or animalism in the whole of that story. He is always doing something to benefit his brethren; his prominent acts are unselfish, though I am not indisposed to allow that, compared with an Infinite Being, the undercurrent unknown to himself may have been selfish. Adversity taught Joseph humility, accordingly he progressed in intelligence; from such characteristics Society arose.

"Society," says Professor Huxley, "differs from Nature in having a definite moral object; whence it comes about that the course shaped by the ethical man—the member of Society or citizen—necessarily runs counter to that which the non-ethical man—the primitive savage, or man as a mere member of the animal kingdom—tends to adopt. The latter fights out the struggle for existence to the bitter end, like any other animal; the former devotes his best energies to the object of setting limits to the struggle. The first men who substituted the state of mutual peace for that of mutual war, whatever the motive which impelled them to take that step, created Society. But in establishing peace they obviously put a limit upon the struggle for existence. Between the members of that Society, at any rate, it was not to be pursued *à outrance.* Without that organization of Society, created out of the toil and blood of long generations before my time, I should probably have had nothing but a flint axe and an indifferent hut to call my own; and even then these would be mine only so long as no stronger savage came in my way." "So that if Society, having—quite gratuitously—done all these things for me, asks me in turn to do something towards its preservation—even if that something is to contribute to the teaching of other men's children"—Society would not, he concludes, "be dealing unjustly with me in converting the moral obligation into a legal one." *

Mankind is thus divided into two leading types—the ethical man who cultivates his intellect for the subjugation of self and welfare of his species; the non-ethical man who cultivates his intellect to increase the gratification of self. These two types are combined in varying proportions to produce diversities of character; just as from the simple images first presented to a child's mind are formed complex and compound complex images. The non-ethical man pure and simple is still to be found in our midst, but owing to the restraints imposed by Society the conditions of warfare are changed; the Savage is veneered; he is found and carries on his depredations, in the form suitable to changed conditions, in all classes of life. Such may be called

* "Struggle for Existence," *Nineteenth Century Magazine*, for February, 1888.

Social Savages, for although prevented by the Criminal Code from what may be termed coarse robbery and violence, yet other methods are open to them of which the law can take little cognizance; such as gambling, drunkenness, seduction and the like, misrepresentation, bribery of all kinds, and slander by look, gesture or word; from any one of these may creep envy, hatred, murder. History abounds in examples, will do so in the future.

When the young of speechless animals can run about and get food independently of their mothers, they live only for themselves; for a time indeed they return and their mothers fondle them, but gradually these latter relapse into a state of indifference—there is no surplus cerebral matter for the retention of, or exhibition of, affection on any other basis than that of relief from distension of the mammary glands. The tie which bound mother and offspring is broken. Similarly also in Mankind in so-called civilized communities the Brats are used for gain and purposes of extortion just as any other chattel may be used. When the children have gained sufficient brain-power to know that they are only made use of and not otherwise cared for, they in turn throw off the yoke and act as independent centres. Many of these, under twenty years of age, marry, get families, and leave their parents to starve; for the latter the workhouse provides, but what is the difference between such offspring and animals? The latter we try to improve by teaching them obedience for use, companionship or gain, whilst the former we neglect. It is evident, therefore, that there must be some other power or influence which should be present, but which is not, either in the parents or children, for moral obligations are either unknown or unheeded when the above conditions exist.

So far it has been seen that the lower orders of creation are endowed with instinct or animal propensities; in the case of the Mammalia is superadded a limited amount of reasoning power which cannot progress because of the absence of cerebral matter. In Man this additional matter is present but in abeyance till called into exercise by cultivation. Man, therefore, possesses the instincts of a lower creation, with the capability of a higher reasoning faculty; his first effort in this direction will be to increase his resources and powers for self-gratification.

In the ages of the world when the male helped the female to nourish the offspring * and supplies were plentiful, both sexes were equally affected towards that offspring, but as the race increased, the struggle for the necessaries of life demanded more vigorous employment from males in the chase or other ways; the double duty devolved solely

* Darwin.

upon the female, who became the embodiment of food, patience and gentleness to the offspring. Remaining at home her susceptibilities were heightened by the frequent cry of her helpless babe and the anxious longing for her lord's return with the means for satisfying their wants. She was not subjected to deadening or hardening influences, the feeling of sympathy was uppermost in her mind. But the man inured to the elements, excitement of the chase and conquest over obstacles, became hard and rough; he expected the same bending to his will which his prowess had obtained in the field. Softer feeling was banished by hardships undergone; at home, obedience only was required, and this was enforced without mercy—more stringent in adversity.

Thus woman became man's slave.

In Western Africa, Du Chaillu tells us that a woman's want of chastity is condoned if she has many children, for the more children a man's wife has, the greater becomes his consequence in the tribe. He further tells us that, a man's chief ambition is to have many wives, from various tribes, to extend his connection and help him in barter or in a palaver; their duty is to cultivate the ground and feed him; obedience is enforced by a whip made of hippopotamus' hide and they are more harshly treated than slaves. These people have a belief in good and evil spirits, in the power of charms and in the significance of dreams. Their religious notions are of the lowest and vaguest kind; superstition is rampant; every man believes what his fancy, by some accident, most forcibly represents to him as hurtful or beneficial. He firmly believes in sorcery or witchcraft and that death is always a violence, brought about by some potent wizard. If he believes himself to be bewitched his whole nature is changed, he is suspicious of all, becomes sick through fear and has frightful dreams which point to some wicked sorceress in the village; the whole village becomes infected by these fears till chance turns suspicion on some one or more unlucky individuals who are forthwith butchered.

On the death of a free man at least one or two persons are killed; but this is not generally the case when women, children or slaves die. They fear spirits of the recently departed and place articles of food, dress and the like on their graves, replaced from time to time. When men and women are slain over a grave, they believe that their spirits join that of him in whose honour they have been sacrificed. During the season appointed for mourning the deceased is remembered and feared, but when once his memory grows dim there is no belief in a prolonged existence of the departed spirit; "after death all is done." They are morbidly afraid of death as it is the termination of all their joys, and out of this fear follow the customs above outlined. They have no belief in a hereafter nor any "idea of a Supreme and Almighty Spirit, Creator and Preserver." They have an idol for the clan, and also private idols which are invoked on important occasions. These are repulsive figures believed to speak, walk about, eat and drink, in short to perform nearly all the functions of a man. They have no priests, only a wise-man and medicine-man combined in the doctor, who exorcises evil spirits and names some unoffending creature on whom the villagers at once pounce, but he has nothing to do with the idol. He also puts power into their charms in which they have implicit faith; there is no one without one or more of these charms upon his person about his neck or waist. Each charm has a special virtue or power. This individual is also consulted on all important undertakings of the village or tribe, and pretends by ceremonies of divination to foretell the issue.*

In the foregoing account there is an absence of all moral sense and not one redeeming feature to atone for the intellectual confusion and brutality of habits. This picture of human life within tropical Africa to-day vividly recalls and revives as it were the customs and manners which pertain to four thousand years ago, and is doubtless a fair representation of that which existed in still earlier ages.

* Du Chaillu's "Exploration and Adventures in Equatorial Africa."

Assuming that the human race was once in a state of complete barbarism, conditions of improvement would depend upon the readiness of obtaining food supplies and the mode of utilizing them, a genial climate (not too enervating nor too rigorous, but with alterations of temperature sufficient to make artificial heat at times acceptable) and permanent settlement. Supplies then being plentiful and other conditions favourable, bodily nutrition would be well maintained and mental activity promoted. Rude instruments for domestic use and the chase would be fabricated from flint and stone, the shelter of rocks and caves, or huts of wattles, stones or earth would be sought, or constructed, for protection from the stronger beasts of prey and inclemencies of weather, whilst rough coverings of leaves, bark or skins would be used for warmth and protection of the sensitive parts of the body.

As the race multiplied, or seasons changed with excessive drought or overwhelming floods, supplies in that district might fail which would necessitate wandering in search of food. This wandering with change of scene would develop observation and mental activity, gradually leading to some attempt to provide against famine by storing the fruits of the earth, acorns for example, for periods when few or none can be obtained—such a store place or Indian "cache" may be seen in the Yosemite Valley at this day. As observation and mental introspection improved, cultivation of the ground for supplies would be the next advance and probably the prelude to a permanent settlement. Dwellings used hitherto merely for shelter, would be made more commodious and be arranged in some degree of order for mutual protection. The manufacture of implements would most likely be attended to by those who had practice and the requisite skill for making them, this would be a beginning of the division of labour.

So far as known, all nations and tribes seem to be imbued with the fear of spirits, which are good when the people are successful and prosperous, and evil when they are overtaken by misfortune whether from climate or other causes. Accordingly human actions go hand in hand with belief. So long as a tribe is prosperous, good spirits will abound and probably multiply according to tribal requirements. In adversity good will be replaced by evil spirits and superstitious ideas begotten of fear arise—possibly accompanied by cruelty.

Prosperity and adversity then may be regarded as natural methods of education—so long as adversity is not unduly prolonged, good and evil spirits will commingle, the one adored from a sense of gratitude, the other propitiated from fear of further disaster—the general result being beneficial in training the intellect to a sense of right and wrong. Improvement, however, does not take place suddenly but gradually and extends over very many generations of men and many cycles of seasons.

From Du Chaillu's description we find families congregated, villages erected, the ground cultivated and language employed. From Darwin's description the Fuegians are destitute of any culture and without language for connected thought. The one is an example of savages undergoing transformation, the other of such in a primitive condition, though some might plead the effect of regression from a better state through long continued adversity, yet the want of articulated language must preclude this plea.

When man had obtained some sense of consciousness, the phenomena of night and day and change of seasons would gradually claim his attention. The motions of the heavenly bodies in further arresting his attention, would lead to a rude knowledge of astronomy; and the more he studied and dwelt upon this subject, the greater in clearness would be his belief in the power of spirits (which he would invest with human forms and appetites), and the greater his necessity for worshipping them. Man thus became a polytheist.

Hence, ample food supply combined with a temperate climate had a powerful influence for instruction in arts and refinement by supplying the frame with those compounds which preserve its integrity and invigorate its intellectual faculties. From this cause may be traced the growth of intellect, and from the study of astronomy that of belief in spirits which hovered round his dwelling. The improvement was slow and tentative but still progressive; as each generation added to the stock of human knowledge, old ideas died out to be replaced by newer, brighter and more perfect images.

CHAPTER XVII.

THE KNOWN AND THE UNKNOWN.

The contents of the Universe were described, in the second chapter, as consisting of two kinds of matter —one aggregated in masses to form stars, sun, planets and so forth, and the other a highly elastic, rare medium, called Ether, possessing the property of inertia but not of gravitation, which fills the whole universe including the interstitial space of all matter, so that by the vibration of a single molecule of matter, undulations of this medium are instantaneously generated and radiated. The frequencies of these undulations lie between 107 billions* and forty thousand billions per second, but the only undulations perceptible to human eyes lie between 392 billions—the extreme end of the red spectrum— and 757 billions—the extreme end of the violet spectrum—per second. The slowest waves are less than 392 billions per second and recognized as dark-heat-waves; if the waves are more than 757 billions per second they are again invisible but recognized as

* Daniel's "Physics."

ultra-violet or chemical rays. The lengths of the slowest are longer than those of the highest, or nearly double their length.

The first kind of matter—solid, liquid or gaseous—is perceptible to our senses and can be analyzed. The second kind is only "an inference from the phenomena to which it gives rise; and if a large group of phenomena find their best or their only explanation in the assumed existence of a form of matter of an unfamiliar kind, the evidence for its existence is of exactly the same character as that on the ground of which we believe ourselves entitled to assert the existence of any kind or form of matter whatsoever." The phenomena of Light and Heat are best explained as undulations propagated through such a medium: Electrical attraction and repulsion are considered to be *local stresses* in such a medium; current electricity to be due to a series of throbs in such a medium when released from stress; magnetic phenomena to be due to local whirlpools set up in such a medium.*

Sounds, however, are waves of compression and rarefaction propagated by all elastic media; they create changes of pressure which affect the drum of the ear and are conveyed to the auditory nerve. In like manner the olfactory nerve is stimulated by the diffusion of odours in the air in contact with a

* Daniel's "Physics."

moistened membrane. These present explanations do not negative the hypothesis that Ether may ultimately be found to take a considerable share in the propagation of both sound and odour. Certainly with reference to sound, the evidence is that it is conveyed only by solids, liquids, air and other gases, for if a bell placed within the receiver of an air pump, from which the air is exhausted, be struck, no sound will issue because there is no air to set up air-waves. That is, a grosser material than Ether is necessary for the conveyance of slow vibrations. Odours, however, are more subtle and cannot be detected by the microscope nor by chemical tests and for their detection the physiological test is alone relied on.

Minerals, plants and animals all more or less give off odours which under certain conditions are perceived by the sense of smell and by that alone.

In the case of some of the lower creation living in a watery medium animals are guided only by this sense, combined perhaps with taste—sight, vision and hearing being either entirely absent or taking no share in the guidance. Bees scent honey at a great distance, making directly for the place where it is to be found. They can scent a stranger in the hive and at once attack though they do not see him. Bee-keepers in joining two stocks of bees are in the habit of using some powerful odour such as peppermint or tobacco to conceal the natural bee-odour from each tribe and so induce amity amongst members of the same hive.

Odours from animal bodies are supposed to have a higher specific gravity than air, being therefore heavier they are more persistent and leave their scent in the track where the animal has been, *i.e.* they are less volatile and do not diffuse themselves so rapidly as other odours. Sportsmen in India and elsewhere make good use of this knowledge as also do the pointer, hound and so forth.

As odours are only determined physiologically, when perceptible to more than one individual they are considered to be objective, but if perceptible to one individual alone they are termed subjective sensations, *i.e.* they are uncorroborated or may be of nervous origin. Among the higher classes of animals the sense of smell is extremely acute and odours are perceived very far off. The vulture scents or tastes his prey at great distances and other wild animals do the same; savages also seem to possess the same power. The boy Mitchell, born deaf, dumb and blind, depended almost entirely upon the sense of smell, or perhaps taste combined, for his communication with the outer world, though, doubtless, he was also aided, as was Laura Bridgman, by the sense of touch.

Again our likes and dislikes to persons, animals and substances arise from properties within them (given off as an effluvium?) antagonistic to those resident within ourselves which produce revulsion. Some persons not only cannot overcome dislike at the sight of certain persons and animals, but even feel their presence without seeing or being cognizant that they are near. What is the medium by which this feeling is conveyed? It must be due either to the sense of smell or some other force acting upon the body through an etherial agency, as in the case of those who suddenly think of an absent or forgotten friend who will be with them presently, or from whom they are about to hear. Clearly the sense of smell can have nothing to do with such a case, nor yet with another case of frequent occurrence, of two people having the same thought at the same time without previous communication and while each one was engaged probably on a mental occupation of diametrically opposite character. It is termed coincidence, and there the explanation ends—and with that explanation if it is one, we must rest content.

From time immemorial wherever men have been found, whether civilized or not, there has been and still is an innate belief, consciousness or feeling of guiding influences or spirits. But as such immaterial objects cannot be made manifest to our senses they must be conceived of as subjective phenomena or powers which elude our cognizance and are incapable of isolation. We see the effects of the power of Life but are unable to isolate it or say in what it consists. Dr. Beale tells us that the elementary parts of every tissue may be divided into *living matter* or *bioplasm* and *lifeless formed matter* produced at the moment of the death of the particles of the first, but this does not explain why or how these particles came to live, or to possess "the adjustment of internal relations to external relations."

Again we feel the presence of danger * or dread of some catastrophe without being able to refer the feeling to any special sense or to account in any way satisfactorily for this sensation. It is spoken of as intuition, but this is no advance in knowledge, for the question recurs, What caused the act of immediate

* A remarkable instance of this sense of danger occurred to me one very dark night whilst endeavouring to make my way, from off the high road, to Cathcart's Hill to view the bombardment of Sebastopol. I branched off within the English lines and supposed I was going safely when I suddenly became conscious of danger. I stooped to outline any object in front but could see nothing, on the left fancied I saw the crest of a hut: calling out loudly "Friend" I walked quickly on to find a Zouave on his knee taking aim with a rifle at his shoulder. He was in shadow and I was probably somewhat illuminated by the bursting bomb-shells. He may have challenged but I certainly heard nothing till arrived at the bayonet's point. This is only one of many instances which occur to others under like circumstances. Three officers went out for a walk in the Chin country, one thought of returning and urged the others to do so—they went on—a surprise party fired a volley and he who had urged his friends to return was shot dead, the others narrowly escaping.

perception? if we call it instinct the position is no way improved; if termed prescience we are no better off. Hence we do not know what that agency is, which warns us of danger or catastrophe or assures us of success, yet we become conscious of what is or what is not for our welfare.

It seems then that if odours are perceptible at great distances by animals to whom the sense of smell is an important adjunct either for subsistence or maintenance of species; and that if in man uneasy sensations occur which cannot be accounted for or be defined either by sight, hearing or smell and yet are perceptible to the individual man, there may exist other influences, comparable with Life, of which at present we are ignorant; and that possibly these influences by setting up waves in the Ether, act upon the sensorium, or recording plate, from which ideas arise and receive shape.

The human brain at birth owing to immature development is physiologically incapable of the inception or reception of ideas; how and when then does it become capable of housing a Soul? We know that the harmonious movements of the body can only arrive at perfection by constant exercise of the nerve-cells and nerves in millions of repetitions. In a similar way the faculty of intellect can only obtain its power through countless repetitions of sensations, sounds and sights. What then is the

Soul? It is not the state of living, because this is common to the vegetable and animal kingdom. It is not instinct, because this is common to all animal life. It is not intellect, because this is the faculty by which mankind may see and know the relation of objects one to another and understand the effects of curbing and relaxing control over instinct. But it is the resultant of action and interaction between instinct and intellect, distinct from both but dependent on the integrity of each and is a faculty possessed by Man alone.

Instinct is a natural impulse which belongs to all living creatures to do what is necessary for the supply of their animal wants. Creatures below the order of mankind have not the cerebral matter to enable them to exercise a power higher than that required for their bodily sustentation and preservation; but in Man the additional cerebral supply enables him to superintend and regulate instinct (or "inherited memory" as it has been called) and subordinate this instinct to intellect.

The thinking or moving principle of Intellect termed Mind must be considered under two forms—objective and subjective. The first concerns itself with material objects, problems and their relation one to another, *i.e.* deals with sensible images or what is immediately under its observation; the second is principally concerned with unknown, immaterial problems of every possible kind relating to those objects, and arises from introspection in searching out causes, elaborating ideas and investigating unreasoned promptings or instincts, *i.e.* it deals with immaterial images or hypotheses, it is the forerunner of progress. Both, however, work together to extend our knowledge in Ethics, Arts and Science.

When an animal or uneducated savage looks at the moving clouds, the stars, sun or moon, except so far as their appearances may presage him good or harm, he thinks not of how they are formed, by what influence they move and twinkle or rise and set. But when Man speculates or exercises his reasoning power beyond the immediate influence that sight confers, he begins to gain knowledge, or a clear and certain perception of that which exists, this increases as his understanding widens; it is a result of education, that is a drawing forth of intelligence to apprehend objects in their general relation one to another.

When men die, their knowledge dies with them, but not before they have imparted the results of their experience and cogitations to their immediate successors. And when the information so gained is found to be of universal application it is transferred by symbols to paper to become the property of posterity. Objective knowledge, then, is capable of proof and transmission, after the death of the scholar or scientist who first offered for consideration ideas on some particular kind of knowledge. So also his subjective ideas on any subject are equally capable of transmission but they are not accepted as knowledge until they have been proved or resolved and become at the hands of others, learning for general acceptance.

In this way subject after subject, veiled in mystery to our forefathers, has by the accumulated labour of individuals been unravelled, till now there is scarcely any matter of primary importance concerning which there is not some satisfactory explanation forthcoming, except the cause of our Being. This is Life—an abstract and abstruse term which at once acknowledges a power superior to ourselves, evinces our ignorance of its origin, authorship and limit.

Life, says Weismann, "is continuous and not periodically interrupted; ever since its first appearance upon the earth, in the lowest organisms, it has continued without break; the forms in which it is manifested have alone undergone change. Every individual alive to-day—even the very highest—is to be derived in an unbroken line from the first and lowest forms."

Life then is the exciting principle of all things living. And living things are divisible into living matter and formed matter, that is inert, congealed, or crystalloid matter. But true crystals grow by accretion whilst living cells grow by intussusception. Hence a cat must eat a mouse, a tiger a bullock and a bullock grass. The cat, mouse, tiger, bullock and grass could not exist or grow were they placed amongst crystals alone, because such particles in that condition cannot supply organic matter, or that which once had exhibited active motion, to repair the loss of particles which have ceased to be serviceable, and to enable the animal or plant to carry on its life movements, but they must take in or intussuscept matters which have not passed into the inorganic condition and become incapable of ministering to nutrition. To these, therefore, vitality comes from without, is stored within and takes the place of that which is rejected or has become inert or crystalloid and no longer serviceable to that particular body.

Life is present in the simple cell, in the multiple cell, and in the agglomeration of multiple cells which form a distinct creature or plant. When such a form ceases to grow or move or exhibit the phenomena of vitality it is termed *dead*, that is, our objective senses no longer recognize it as living under a changed or passive condition. "The real proof of death," says Weismann, "is that the organized substance which previously gave rise to the phenomena of life, for ever ceases to originate such phenomena. This, and this alone, is what mankind has hitherto understood by death." Yet "the limitation of life in single individuals by death is not, as has been hitherto assumed, an inevitable phenomenon essential to the very nature of life itself, but . . . is an adaptation which first appeared when, in consequence of a certain complexity of structure, an unending life became disadvantageous to the species. . . . Among unicellular organisms natural death was impossible, because the reproductive cell and the individual were one and the same; among multicellular animals it was possible, and we see that it has arisen. . . . I consider that death is not a primary necessity, but that it has been secondarily acquired as an adaptation. I believe that life is endowed with a fixed duration, not because it is contrary to its nature to be unlimited, but because the unlimited existence of individuals would be a luxury without any corresponding advantage. . . . The organisms did not finally cease to renew the worn-out cell material because the nature of the cells did not permit them to multiply indefinitely, but because the power of multiplying indefinitely was lost when it ceased to be of use." *

Granting that what Weismann says in general is true, yet the question naturally arises, What is the

* Weismann, Duration of Life, "Essays on Heredity."

factor which determines the cessation of such power in an organism? All organic matter is endowed with life either active or passive. Active life is manifested to our senses by nutrition, growth and multiplication. Passive life is the absence or cessation of these acts, or the change from a positive to a negative condition, that is, functions are not performed by the particles of the organism. A grain of wheat is not dead because under one condition it gives no evidence of life, whilst under another it does. If placed in the ground it may exhibit active life, or in place of growing, may resolve into its component parts. And since the molecules of this seed, or those of an animal body, giving evidence of a negative condition can thus resolve themselves and rearrange their constituent elements for utilization, and again exhibit to our senses intrinsic movements under other forms, it is clear that those particles were not deprived of their function of motion and use, but simply ceased, however cessation was brought about, to carry on compound multiple movements, in the particular forms in which they had been associated. The two conditions though opposed, determine the manner in which external forces shall operate, for the power which produces activity for increase, is the same which produces passivity for decrease or dissolution in an organism. This unknown function constitutes the subjective form of life which we are unable to comprehend. Active "Life, then, is not a property of matter but something superadded thereto whose amount may be increased by generation through organized structure, and by means of the various forces of nature; but certain conditions are essential to its continuance, although in themselves incapable of originating it." *

It is natural, therefore, to refer this subjective life principle, or power, to a first Cause, Intelligence, or Spiritual Being which exists in the Universe, and which all nations of whom, from the earliest dawn of thought, there is any account, have independently acknowledged and reverenced as Heaven Father:† an all-powerful; all-wise and universal Good, or God.

Some call this creative, or life power, "Necessity" or "Nature," but it does not much matter what term is applied since Man admits an unseen process, or an immaterial power, he cannot grasp.

The possession of a Soul is admitted to be something different to, though intimately correlated with life. It is an immaterial product not quite capable of proof but an Entity inferentially calculated from probability. Life in Man has been called the Soul of Man, but this is evidently a mistake, for extended intelligence is not moved by a power, or process

* Professor Haughton, "Laws of Vital Force."

† Max Müller's "Science of Religion."

different to that which moves the lower orders of the Mammalia in their limited objective intelligence, and they are not credited with the possession of extended intelligence.

The Soul I conceive to be a chastened form of instinct, emotional in its origin, begotten of gentleness and persuasion from one animal body towards another, and reciprocated. As the brain develops it increases in strength, it grows and enlarges its powers of understanding; up to fourteen years of age at least this young soul requires a Mother's incessant care and not the care of an alien—too much in vogue.

Some think the Soul is Heaven-sent and enters the body before or at the moment of birth, but if so when the earthly tenement collapses surely it should return whence it came.*

This some theologians deny, for they consider the Soul as a possession, a sort of marketable commodity which after death can be dealt with according to the life led by its possessor, or his latest aspirations coupled with certain forms and ceremonies. This may be satisfactory and comforting to immediate friends in some cases, for the essence of Souldom is Love, and where this has been the leading principle

* What can be more horrible than the doctrine of some Christians (?) of the fate of an infant's soul a few days or weeks old if it should die unbaptized? How can a human creature save or condemn by a ceremony?

of the life of the deceased, undoubtedly it is a consolation; but he who has not loved the brother he has seen, and yet had the power or the opportunity of ministering to his wants, he cannot exercise that function hereafter; Eternal happiness could not be appreciated, simply because he had not been accustomed to it. It would be like expecting a man to sing in unison with a selected choir without training. Sympathy, then, like symphony, requires practice, and the only opportunity men have for this practice is on earth. If we merely sympathize with ourselves, look with aversion on children and neglect our neighbours, we are acting now for the present exclusively, and with no more heed to a future life than the soulless brutes whose intelligent capacity is centred in themselves.

The earliest manifestation of Soul in the human race arose in the conduct of opposite sexes towards each other—this was a purely animal instinct termed love or affection. The next step was the bond of sympathy and dependence between Mother and offspring, for each was and still is dependent upon the other. As affection on the one hand is encouraged by gentleness shown to helplessness, so on the other the grateful, winning, caressing and dependent embrace of the helpless one increases the sympathy of its Mother. The woman's efforts to influence her lord and master, and the Mother's devotion to her child enlarge their views of relationship and love towards one object; these efforts extend to others who may preserve or assist to preserve from injury the cherished object, and thus the bond of union is strengthened and extended.

At first, the babe is educated through touch. He learns to appreciate gentleness and distinguishes between a stranger and his regular nurse; by sustenance he grows, he becomes plump through the satisfaction which gentleness conveys to the central system, soothing nervous tumult, a necessary result in the progress of growth and vigour under changed circumstances. When the sense of vision is established he is at first attracted by strong lights, but as the sensibility of the retina increases he differentiates between strong and feeble light; misty appearances take shape in more definite forms; outlines are separated one from another; then, details of persons and faces are recognized; he knows the nurse from the mother. This effect does not happen with the rapidity usually imagined but takes place very slowly. Taste, smell and sound come in the same way.

The next step in knowledge is to connect actions with form, he crows and chuckles with delight as he views preparations for feeding connected with satisfaction for his stomach. In the same way he connects sounds with sight. The opening of the door, or the tread and appearance of his Mother, or the rattle of the bottle by the nurse, has an end which he understands. All this is spontaneous attention, a condition of instinct and an emotional state. The Mother is the child's idol and *vice versâ,* their instincts are intertwined. There is one bond alone between them and that bond is Love. Love permeates the body, influences the actions and is reflected in the countenances of those who cultivate it; it grows, is nourished and increases by sympathy and gentleness; it is starved and grows small by neglect and roughness—the flame of a match becomes smaller and smaller till it ceases, a red glare alone is left to keep light, how long?

As the little one grows and stores its mind with images, a watchful mother guides the unfolding intellect and teaches the child to reason upon the instincts in which it has been reared, and makes it feel that obedience or subordination of self is the ruling principle of intellect and civilization. There is then a mutual instinct and interdependence of one being upon another, guided or aided by intellect to create a third influence. This third influence is the Soul, a product of art, education, direction and training; it arises from natural affection and finds in the latter its conditions of existence. Hence in infancy a seedling Soul is sown, and cultivated in our early years with care and diligence by the influence of the Mother; it is made a stout, hardy, little plant before sexual passion is developed. Principles firmly rooted withstand the storms of puberty; the soul of such a child walks forth by aid of those examples and precepts to which it has been accustomed; its tenement, graced with goodness and innocency of action, finds strength and satisfaction in ministering to the want and comfort of those who are in sorrow, danger, distress or poverty. Like the hardy oak whose roots are in good soil, it defies the storms of life and is an encouragement and shelter to others who rest beneath its shade.

In the case of animals, the bond of sympathy ceases when the need for dependence is over; but in civilized human beings this animal instinct is brought under the control and influence of the intellect: a sense of responsibility is awakened, which grows the more it is encouraged. From this feeling there originally arose an idea of moral obligation and mutual dependence sufficient to give one being a right to intercede with, influence or command another. But many generations of prosperity and settled abode passed away before any code of unwritten customs could be formed, and many more before any thing like a Soul as now understood, could be formulated.

If the Soul, then, be regarded as a growing faculty which uses the body as its tenement, its feet resting upon Earth whilst its aspiration is in heaven,* or towards that whence all goodness flows, it is evidently a cultivable quality, evolved by education and not an inherent one. It is full of trustful confidence and belief in truth. It knows not fear because it is love, and love and fear cannot dwell in the same house. It thinks no ill towards, and knows no ill of its neighbour, but seeks to help him in all things, to warn him of danger, to aid him for good, and prefers his success to that of its own. This is the perfection of a Soul, charity or the highest love—only such a Soul can be pure and holy for the life to come.

Granting the above theory of the origin of Soul to be correct, the first step in progress for primitive man, would be a belief in the Soul as the Spirit which dominates Man during life; for a time hovers over his remains, and requires sustenance, which is provided so long as the impression made on the survivors by his earthly career lasts; but through his absence in the daily routine of life this impression grows dim and is finally forgotten. But as progress in memory, thought and observation improved, the Spirit, in the imagination of survivors,

* Mobilitate viget, virisque acquirit eundo;
Parva metu primo; mox sese attollit in auras,
Ingrediturque solo, et caput inter nubila condit.
Virgil, Book iv. line 177.

would be translated to happier hunting grounds; whence arose the further necessity for providing the deceased in his grave with the weapons of war and the chase. In time, on the site of his remains a tomb, ultimately converted into a temple, would be erected in his honour; where his spirit on return from war or the chase might be expected to dwell and where it would be supplicated for assistance in the various avocations of life.

Thus the human race, by cultivating superstitious reverence and devotion to the memory of deceased friends, relations and benefactors, endowed the spirits which had animated those remains, with a longer tenure of immaterial life; this paved the way for the system of mythology introduced by Thoth among the Egyptians, 1521 B.C., and perfected by the Greeks at a later period. But the Soul, as we at present conceive it, is a conception for which the learned nations of Antiquity were not sufficiently advanced. Up to nineteen hundred years ago, we know that a considerable section of the Hebrews did not believe in the Immortality of the Soul. Hence the idea of a Soul living for ever is a notion of yesterday, compared with the duration of Man upon earth. It is an effect of education and of the enlarged powers of the understanding.

At birth a child has animal life and no more, but as its intellect grows it subordinates instinct and acquires a Soul ; hence the importance of an infant's surroundings, and the beneficial effect which must attend the labours of those who spend their time in visiting the poor and outcasts of Society—

> "Ingenuas didicisse fideliter artes
> Emollit mores nec sinit esse feros."

"The child is not insensible to the influence of example. Even in the earliest years the manners, the language, the principles of the elder begin to mould the character of the younger. . . . The moral atmosphere must be brutish indeed which can do deep harm to a child of four years. But what is harmless at four is pernicious at six, and almost fatal at twelve. . . . He instinctively copies those whom he admires, and in doing so imbibes whatever gives the colour to their character. He repeats opinions without really understanding them, and in that way admits their infection into his judgment. He acquires habits which seem of no consequence, but which are the channels of a thousand new impulses to his soul. . . . The power of example probably never ceases during life. Even old age is not wholly uninfluenced by society ; and a change of companions acts upon the character long after the character would appear incapable of further development. The influence, in fact, dies out just as it grew ; and as it is impossible to mark its beginning, so is it to mark its end. The child is governed by the will of its parents; the man by principles and habits of his own. But neither is insensible to the influence of associates, though neither finds in that influence the predominant power of his life. . . . Elementary truths are the hardest of all to learn unless we pass our childhood in an atmosphere thoroughly impregnated with them; and then we imbibe them unconsciously, and find it difficult to perceive their difficulty." *

* "Essays and Reviews," Education of the World.

CHAPTER XVIII.

PRIMITIVE RELIGION.

The first generations of men had neither temples nor statues for their gods, but worshipped in the open air looking towards heaven. The Greeks invested their gods with human shape, but the Persians did not do so, for they had neither temples, images nor altars and thought it absurd to confine within walls the gods whose house and temple was this whole world; they only sacrificed upon some high place. For this reason it is supposed that Xerxes, 464 B.C., burned and demolished the temples of Greece. High mountains were held sacred from the idea that tops of mountains approached nearest to the seat of the gods. Hence Hector, says Homer, was commended by Jupiter for the many sacrifices which he had offered upon the top of Ida.* Human sacrifices originated with the Chaldæans, from whom the custom passed into other Eastern nations; it was doubtless a common practice in the time of Abraham, who ascended a mount in the land of

* Dr. Potter's "Antiquities of Greece."

Moriah to offer his son as a burnt offering, and was only too glad to escape the ghastly custom by the fortuitous advent of a ram.

Both at Athens and Rome the most sacred temples stood in the most eminent part of the city. As the majority of the gods were men consecrated on account of some public benefit conferred on mankind, so most of the heathen temples are thought to have been, at first, only stately monuments erected in honour of the dead. Thus the temple of Pallas, in the city of Larissa, was the sepulchre of Acrisius; Cecrops was interred in the Acropolis of Athens, and Ericthonius in the temple of Minerva Polias, to mention no more. In Hesiod's time, 900 B.C., it was said, "there are thirty thousand gods, inhabiting the earth, subjects of Jupiter and guardians of men." Before temples were built, altars were erected in groves, and previous to their introduction, sacrifices took place on the bare ground. The first account of an altar is that of Noah, 2348 B.C.; afterwards that of Abraham in 1921 B.C. Cecrops is said to have been the first king who raised an altar, in 1556 B.C. Among the Greeks there were two kinds; high altars and lower ones, which differed according to the diversity of the gods to whom they were consecrated. To the heroes they sacrificed upon altars close to the ground being only one step high. The Infernal gods instead of altars had little ditches or trenches digged or ploughed up for that purpose. Nymphs and such like deities had religious worship paid to them in caves instead of altars. Altars were made of earth, or of the ashes of burnt sacrifices; of horn and of brick, but commonly of stones. Terrestrial gods had their altars erected in low places but Celestial gods on the tops of mountains. Among the Athenians there was a custom that obliged them to entertain a great many strange gods. Nay, so fearful were they of omitting any, that Pausanius tells us, they erected altars to Unknown Gods. But these were not permitted to be worshipped until they had been approved, and admitted by the Areopagites. Hence Socrates lost his life. Such an altar St. Paul found, and cleverly used this custom for preaching his own doctrine. Altars were oblong, square or round, and the most ancient were adorned with horns. The name or proper ensign or character of the deity to whom they belonged was engraved upon them.*

It is uncertain who first introduced the worship of idols. Belus was made a divinity after his death, and his son Ninus who founded Nineveh 2059 B.C. is said to have been the first to introduce the public worship of idols, but doubtless most families had their household gods or penates, on which they set great store, or we should not have at a later period

* See Dr. Potter's "Archæologia Graeca."

the story of Laban pursuing Jacob for them, as narrated in the thirty-first chapter of Genesis. Dædalus, a descendant of Erechtheus who died 1347 B.C. was the first to make two separate feet, whereas before his time idols were but of one piece. At first they were oblong stones, and are supposed by some to have originated with Jacob, but it is more probable that such stones existed as objects of worship long before his time as in the Runes of Scandinavia, and other places.

The Lacædemonians had a law that every one should serve the Gods with as little expense as possible, herein differing from all other Grecians; and Lycurgus, 884 B.C., being asked for what reason he made this institution, so disagreeable to the sentiments of all other men, replied, "Lest at any time the service of the gods should be intermitted;" for he feared that if religion should be as expensive as in the other parts of Greece, it might some time or other happen that the divine worship, out of the covetousness of some, and poverty of others, would be neglected; and he wisely considered, that magnificent edifices and costly sacrifices were not so pleasing to the gods, as the true piety and unfeigned devotion of their worshippers.*

In the earlier ages of the world animals and plants were seen to grow, but of their compound

* Dr. Potter.

and complex nature nothing was known, till Science resolved them into their component parts. Similarly phenomena of all kinds for which knowledge could not then account, were regarded with mysterious awe. But now growth and every kind of phenomenon can be traced to a beautiful and natural organization, with an inherent law governing progress due to the still undiscovered power—Life.

If the same analytical process is applied to objects not material, we must not imagine we have reached a finite result, but only a speculative one, the consideration of which may lead to clearer views of our duty in life.

To epitomize, the spirits of the departed were supposed at first to hover for a time over their remains and then to be no more; longer life was accorded to them afterwards, and finally, indefinite duration. Each spirit, a unit in itself, helped to people the world with immaterial forms, and created polytheism; but as the claims to reverence of minor immaterial forms died out one by one, the greater and more conspicuous forms alone remained; and finally only one dominating spirit remained to hold in subjection the minds of mankind. The first nation on record to formulate such a proposition, was the Hebrew Race, which nearly four thousand years ago, from innate superior cerebral organization, and from devoted regard for its tribal god, elected it a controlling power or Deity. This consummation could only be arrived at by a very slow process. It probably was accented by Abraham through gratitude for the good offices of Pharaoh, it culminated on the safe escape of his son, and was transmitted to the rest of his offspring.

"When men pass from a state of pure fetishism, the next conception they form of the Divine nature is anthropomorphism, . . . diffused in a more or less modified form over the belief of almost all uncivilized nations. Those who have ceased to attribute power and virtue to inert matter, regard the universe as the sphere of the operations of spiritual beings of a nature strictly analogous to their own. They consider every unusual phenomenon the direct and isolated act of an unseen agent, pointed to some isolated object and resulting from some passing emotion. The thunder, the famine or the pestilence is the result of an ebullition of spiritual anger; great and rapid prosperity is the sign of spiritual satisfaction. But at the same time the feebleness of imagination which in this stage makes men unable to picture the Deity other than as an unseen man, makes it also impossible for them to concentrate their thoughts and emotions upon that conception without a visible representation." *

Idolatry may be of two kinds, says Mr. Lecky. It

* Lecky's "Rationalism in Europe," chap. iii.

is sometimes a sign of progress when men carve matter into the form of an intelligent being and attribute to it a divine character. Sometimes men who have once risen to the conception of a pure and spiritual Being, sink, in consequence of some convulsion of society, into a lower level of civilization, they then attribute to those representations an intrinsic efficacy. As long as the anthropomorphic stage of society continues, the true history of theology, that is, the emotional and realizing parts of theology, are found in the history of art. "Two ancient nations in which the æsthetic development failed most remarkably to keep pace with the general civilization were the Persians and Egyptians. The fire that was worshipped by the first formed a fetish,* at once so simple and so sublime, that it rendered useless the productions of the chisel; while the artistic genius of Egypt was paralyzed by a religion which branded all innovation

* "Fetishism," says Max Müller, "is a later stage of religious development;" he sums up his argument in four propositions as follow:—

The word fetish must include almost every symbolical or imitative representation of religious objects.

Among a people who have a history, everything which falls under the word fetish points to historical and psychological antecedents, and we are not justified in assuming it to be otherwise amongst people whose religious development happens to be unknown and inaccessible.

No religion is entirely free from fetishism.

No religion consists entirely of fetishism.—"Origin and Growth of Religion."

as a crime, made the profession of an artist compulsory and hereditary, rendered the knowledge of anatomy impossible by its prohibition of dissection, and taught men by its elaborate symbolism to look at every natural object, not for its own sake, but as the representative of something else." *

The elegant mythology of the Greeks was an elaborate system of anthropomorphism with Mount Olympus for its home. Its inception was pure and elevated, as such it was reverenced amongst the philosophers and rulers of Greece. As mankind increased, the priesthood fell into the hands of designing and ambitious men, who to increase their power and gains, multiplied the number of Gods and degraded the system with coarse sensuality; thus by its inherent clumsiness it fell to pieces, to be replaced by a simpler form.

When the Israelites arrived in Egypt 1704 B.C. their manners and customs were not dissimilar to those of the people they went to dwell amongst. They were of one family, the offspring of a founder who having no family, could more easily transport himself from place to place and enlarge his knowledge of human nature; he trusted in his own experience and the protection of a tutelary spirit to guide his steps. When an old man full of years and wisdom, he had a Son to whom he imparted his

* W. E. H. Lecky's "Rationalism in Europe," chap. iii.

knowledge and whom he was about to sacrifice, in obedience to the voice of conscience and, to the universal custom of the people of the country. The fortuitous advent of a ram in the wilderness impressed his mind and changed the current of his thoughts and belief. The terrible dilemma between duty and affection, from which he had just escaped revealed both the needlessness and impropriety of such a sacrifice when other means were available. His understanding, enlarged by the right use of intellect, added dignity to his character: his fame for wisdom spread, and though human sacrifices did not cease yet a blow had been struck as a record against the practice. Henceforth, Abraham would regard Conscience used with intelligence, as a guiding power to be worshipped as Yahveh; and he would be circumspect in the choice of a family from which his son, so miraculously saved, might choose a wife, one who would not unduly influence and turn him from his father's faith. Aided by Isaac, who appreciated his father's wisdom, this faith was transmitted to and developed by Joseph.

Jacob married the daughters of Laban whose images Rachel carried off; he began life by defrauding his brother and deceiving his father, to be in turn deceived by Laban, and also by his own wife and his children. The standard of morality and religion was not high in this family, for there was a mixture of principles and religious feeling which could not but influence the elder children; to this in part may be attributed their dislike towards Joseph whose simple, poetic mind was a bore to his brethren. They were engaged in active, practical out-door pursuits, exposed to toil and hardship, whilst he, a boy, was carefully tended by his mother; his father's special favourite, the son of his old age and possible representative in the future; doubtless he imbibed the traditions of his grand-parents, and the faith handed down to his fathers. Thus, the gentle influences of home life and a loving Mother were continued into late boyhood; the effect of not sharing the rougher pursuits of his brethren, was to mould his mind in a reflective vein, and enable him to perceive the advantages of discipline and obedience to his parents, added to an earnest belief in the protecting influence and guidance of the chief tutelary deity.

When the sons of Jacob went down into Egypt they were a united family with a race or tribal religion of their own; they were polytheists with Yahveh as their helper or head God. They were a pastoral people in constant communion with natural objects, having a reverence for the memory of their ancestors and a firm belief in their own present and future superiority; this kept them distinct from the Egyptians with whom they lived in amity long after

Joseph's death; possibly they occupied some of the principal posts in the State. The history of Joseph was not lost, it doubtless was their example and the centre of their aspirations. That a good-looking youth of seventeen years should resist the overtures of an unscrupulous woman, and ultimately rise to considerable power, was an event not to be forgotten in that lawless age, nor in a race emerging from barbarism. Joseph had learned humility by rough treatment at the hands of his brethren, and the impulses of his youthful and generous mind were quick to discover good and ill. Being of a noble disposition he was thus enabled to profit by misfortune, and to control his passions. Naturally, therefore, he was regarded as a prodigy of virtue and chastity, setting an example of duty to his neighbours for all generations in future to cherish. The details of his life would be carefully remembered as recording that virtue which is a cardinal point in the morals of the world, and a pivot around which character revolves.

"Among all the vices which it is necessary to subdue in order to build up human character, there is none to be compared in strength, or in virulence, with that of impurity. It can outlive and kill a thousand virtues; it can corrupt the most generous heart; it can madden the soberest intellect; it can debase the loftiest imagination. But, besides being so poisonous in character, it is above all others most difficult to conquer." And as a power of evil it "has inflicted, and may yet inflict, more deadly blows than any other power we know of." *

The repose which the offspring of Jacob enjoyed in Egypt during the eighteenth dynasty, consolidated as first principles in this race, the power of a supreme or chief God as Yahveh and the virtue of chastity. When the nineteenth dynasty was established "there arose up a new king over Egypt which knew not Joseph," and the Israelites, in consequence of the war waged against the Races in Canaan, were regarded with jealousy and dislike; their numerical superiority and consanguinity with the conquered races caused them to appear formidable lest they should join also their enemies, and fight against them; thus "the Semitic stranger ceased to be honoured and powerful in the land of Egypt;" † then their downfall commenced and the oppression graphically recorded in the first chapter of Exodus followed.

At the birth of Moses this oppression was in full force; we know how he was saved from destruction by Pharaoh's daughter and educated in all the learning, knowledge and religion of the Egyptians and of the Assyrians also, as we know from recent dis-

* "Education of the World."

† Prof. Sayer, *Newbury House Magazine*, Sept., 1889.

coveries that there was literary intercourse between Assyria and Egypt. But he was nursed in childhood by a Hebrew woman, and became imbued with the traditions and beliefs of his family, which laid the foundation of his ambition and future action. When grown to man's estate he was not slow to sympathize with and endeavour to redress the wrongs of his countrymen; with what success we are aware, for he was in consequence forced to seek a home for many years in the land of Midian.

In his banishment Moses perfected a system of moral, sanitary and religious laws, combining the better parts of the worship of Osiris with his firm belief in the superiority of his family's dependence upon El.* During this period we may be sure that

* "Jehovah is to be regarded as having originally been a family or tribal God, either of the family to which Moses belonged or of the tribe of Joseph, in the possession of which we find the ark of Jehovah, and within which occurs the earliest certain instance of a composite proper name with the word Jehovah for one of its elements (Jeho-shua, Joshua). No essential distinction was felt to exist between Jehovah and El, any more than between Asshur and El; Jehovah was only a special name of El which had become current within a powerful circle, and which on that account was all the more fitted to become the designation of a national God." "The name Israel means 'El does battle' and Jehovah was the warrior El, after whom the nation styled itself." Jehovah was considered to be one who judges and recompenses men not after death (then all men were thought to be alike) but upon earth. This word is older than the time of Moses for it enters into the name of the mother of Moses—Jochebed.—"Encyclopædia Britannica," articles "Israel" and "Jehovah."

his educational and powerful intellect was not unobservant of the events which were taking place in the wars between the Egyptians and Canaanites, and as soon as he perceived that the time for action had arrived, he returned to the land of Goshen, announcing his authority from El to lead his countrymen to that country from whence they sprang.

During his absence the Hebrews had been subjected to tyranny grievous to be borne; they were broken in spirit with no one to guide them, and they could, now, estimate at its full value the sacrifice he had formerly made on their behalf. When, therefore, he reappeared they were ready to accept his sympathy and hail his puissance. His boldness and courage, commanding and dignified utterances found favour with his countrymen and stamped him, who dared to brave the mighty monarch of Egypt, as a leader of men, whom they were ready to follow. However unbounded the confidence Moses had in himself, his confidence in the ability of his God, El, to aid his project was still greater; this was the Power: that which Moses urged should be done, was to be done by that Power whose agent he was.

When Moses had delivered the Hebrews out of the hands of Rameses the Second and crossed the Red Sea, he was too astute a leader not to seek a fresh revelation of power from his God El. Consequently, as Olympus was the home of the Gods of the Greeks, we are not surprised to find Sinai selected as the home of the guiding Power or God of the Hebrews: everything that occurred in the future was to be done by appeal to the God on Sinai. Moses, as an Interpreter of the wishes of El, was well aware that, to keep up this influence in the mutinous throng he was conducting to the land of Canaan, he must inspire hope, and raise their enthusiasm by constant and solemn assurances of easy conquest over the Canaanites whose land flowed with milk and honey: he had an Herculean task before him.

By wise laws and precepts he first had to reduce this unruly multitude to civil order, by a code of regulations to train them to obedience, in which the powerful name of Yahveh was the Master Spirit; he next had to make Soldiers of such as were able to bear arms, and doubtless had to fashion weapons for them; then they had to be trained to the use of these weapons. All these events took up time before the Israelites were sufficiently ready to assume offensive operations. Although the nations they were about to attack were enfeebled by their wars with the Egyptians and would probably be little able to withstand their fanatical attack, yet Moses was too observant a genius to lead his followers, insufficiently trained and badly armed, against even an enfeebled foe long accustomed to warfare. We are not, therefore, surprised at his deliberation and his wisdom in delaying the decisive moment. For he had not been encouraged by the behaviour of the people during his temporary absence, on Mount Sinai (whither he had gone to engrave the tables of the Law) to trust the precious interests involved in the Exodus, of which he was morally the guardian, to those who could not control their passions and who on the slightest check gave way to impatience: moreover he was neither so young nor so active as when he first espoused their cause; he did not feel equal to undertake an arduous and lengthy campaign which he foresaw must be completed by younger and more active men; he was, therefore, content as a wise Legislator to discipline and mature those forces for the successor who should lead them to victory.

In conclusion, the history of Joseph enunciates the wisdom and necessity of chastity, and that of Moses implicit faith and belief in an unseen, guiding Power. To these circumstances then the Jewish nation owes its "settled national belief in the unity and spirituality of God, and an acknowledgment of the paramount importance of chastity as a point of morals." *

* "Essays and Reviews," Education of the World.

It is unnecessary to pursue further the development and change produced in human thought and action by these settled principles; that is for others to work out. The task I originally sketched out is completed, but some may think I have transgressed by the introduction of biblical subjects and characters, yet such subjects are, or should be, so interwoven in early teaching that they become a part of ourselves and influence our mental conception of what is good and great; again, many fail to perceive that the early biblical characters are the connecting links between the savage and the civilized man, and those from whom have grown those fixed ideas which now are the inheritance of mankind. The early biographers who composed the books of which our Bible is made up, appreciated the initiative of superior thought, and therefore, invested the Hebrew patriarchs, in the circumstantial narrative we possess, with the ideas and knowledge of a later age when religious enthusiasm and wealth of intellect were luxuriant.

In utilizing these early characters to sustain the argument, attention must be drawn to the obscurity in which their histories are involved, and the caution necessary to be used in assuming they knew more than they were justly capable of knowing, but which the poetic enthusiasm of that age accorded them. My observations I trust will not be misunderstood nor considered irreverent, for their introduction was no part of the original design but grew out of the argument, and the deduction probably will offend no one.

Summary.—The whole universe is filled with matter attenuated, or aggregated in masses. In one particular part a nebulous mass has been differentiated into a Sun with attendant Satellites, called Planets, which in their turn have developed offspring. The Earth and her Moon form one of such bodies. When the Earth became sufficiently cool to develop vegetable and animal life—in consequence of her great intrinsic heat—the productions were of gigantic proportions and rapid development, but as intrinsic and extrinsic heat decreased, these structures gradually dwindled in size but improved in quality.

When the race of Quadrumana appeared, the Earth had become so cold that *this highest expression of four-footed beasts,* to the exclusion of other kinds, was enabled to assume the erect posture; previously to which—in consequence of the enervating climate —these quadrupeds required the aid of four legs to enable them to sustain their weight in traversing the Earth, just as is seen at present in the Human Infant which crawls on all fours before it is enabled by growth to stand upright.

This alteration in attitude gave a greater power of observation to the animal and naturally increased its intelligence. This alteration was slowly improved by intercrossing till at last a more perfect variety of animal was produced in the Genus Homo. Though possessed of Cerebral development, he was for many thousands of years, in no better condition than the wild men in Ceylon, or gross savages still existing in other parts of the world: this condition improved when food became plentiful, location permanent and climate suitable. Thus assured, Man's intelligence taught him to be less dependent upon the seasons for supplies, and that at certain periods of the year he should gather and store his crops. For this purpose his attention would be arrested by the regularity of the rising and setting of the Sun and Moon and his power of observation enlarged. Hence Astronomy is the first and oldest Science cultivated. His next step in advance would be the influence of those he had cherished in life, and whose departure by ceasing to breathe, was a mystery. Their memories would for a while be revered and their influence prayed for—thus prayer, intercession and polytheism gradually arose; but many ages passed before belief in the unity of the Spirit was formed in the mind. In its earliest conception polytheism was mixed with sensuality; but the influence of the noble characters of the

Patriarchs, accented in the persons of Joseph and Moses so impressed the inhabitants of the world with their wisdom and improving morality that polytheism lost ground and sensuality decreased as an adjunct of religion.*

But the Unity of the Spirit which up to eighteen hundred years ago had been taught by the Prophets alone then met with an antagonist in materialism. At this critical juncture, therefore, in the world's history, when intellect was riding rough-shod over spirituality and materialism was on the increase, the unity of the Spirit became paramount, and the immortality of the Soul pronounced in the person of Christ.

Christ must be thought of as the representative and embodiment of that Spirit which animated the patriarchs and prophets. This Spirit was so far-seeing and authoritative, so pure and exalted that the formalists of that day were dazzled, confounded and silenced *en masse.* He was the incarnation of intellectual as opposed to animal love; its transcendentalism was superb; it was felt in his manner; it was breathed in his words and circled around him; it infected the simple and gave grace to the lowly. This love is still circling around us and however much it may be drawn upon it cannot

* The ancient Egyptians had an idea of Monotheism, but it was mixed up with the basest Polytheism.

diminish; it grows by fission, and like the unicellular or simplest of all cells, it has an unending life.

The voluntary death of a human being for the purpose of proclaiming so holy and benevolent a principle is an example which will never be paralleled. It was a sacrifice designed for imitation, to emphasize the necessity for self-control, to inspire new life and ideas concerning that spirituality for which He suffered; and for the arrest of materialism by the doctrine of the immortality of the Soul, but not of the body as inculcated.

The man who loves his neighbour as himself (even to the laying down of his life) cultivates a pure and wholesome mode of thought and can have no other object than that of benefit to his neighbour; this is reflected back by the consciousness of having done his duty; and in doing this duty he is worshipping the unknown Power and Author of endless life. This Power he cannot see, but the acknowledgment of an influence out of, and stronger than himself assists his progress in consciousness, and raises him above the beasts which have no understanding.

Lastly this love leads him to a belief in a future state of existence where he may once again and for ever minister to the human spirits he loved upon earth; this ennobles him as a citizen, it renders him not only better able to fulfil his duty to his neighbour, but also to follow in the footsteps of Him who (amongst all classes of religious teachers) is admitted to have lived a blameless life, endured temptation, privation, indignity and death for the welfare of his neighbour, for said He "I, if I be lifted up from the Earth, will draw all men unto me."

If then a man will lay down his life for his neighbour, it follows that the principle which prompts this sacrifice is the highest of which man is capable, therefore this principle should be the Guide directing man's duty upon earth. It is true that the Creator comes before the creature, but it is only through the latter that Man can render homage due to the former, for if he loves not those with whom he is in constant association he cannot possibly love or render homage to a Creator. By what Agency then is this principle to be acquired ?

Those who have done me the favour to read thus far will remember that in every period of the earth's history animals and plants in each succeeding epoch of time were of a higher order than in the preceding one. This improvement was not by leaps and bounds, but by regular and slow development assisted by climatic conditions. From the first there was impressed or understood, but unexpressed, control or government.

Control may be defined as a slow, regular, progressive movement of particles or impulses which never stops; each moving particle or impulse has a forwarding and restraining power whereby one particle or impulse cannot precede another till its turn arrives; there is no scrambling for place because each particle or impulse is balanced. This movement may be likened to the grains of sand which move in the cone of an hour-glass, where gravitation is the determining power. Control, therefore, consists in the accurate adjustment of power in one movement, or in one impulse to that in another.

The Control applicable to the growth and improvement of species is also applicable to the growth and improvement in the intellectual faculties —the one being by particles the other by impulses. The lower animals have instincts, or unreasoning promptings to action presided over by the requirement of their bodies; when these requirements are satisfied the instincts remain in abeyance, till again called up by a fresh need of the system. In the human race there are the same instincts, but, in addition, intellectual faculties for a different series of events; otherwise, they would have no meaning since they are not required in the purely animal world. It is true they enable man to increase and supplement his bodily comforts, but this again is subservient to a higher and more intelligent purpose or end.

The growth and improvement, or the decay and degeneration of the bodies of animals are then under natural laws of a complex character which need not be inquired into: and although mankind is under the same natural laws, yet these laws are interfered with by a new factor—intellectual power. In consequence of this power, Man in the pride of his growth assumes to himself a divine origin, he despises the forms out of which he has sprung and looks with envy or contempt upon those who differ from himself in rank whether it be high or low; in wealth whether it be much or little; in intellectual power whether it be strong or feeble. He believes himself to be born perfect and forgets that rank, wealth and intellect are but accidents of birth, and if deprived of them he would be no better off than the rest of the animal creation he despises. The first lesson, therefore, he has to learn is dependence, and the second is to accommodate this dependence to that of others of his own kind, since it is only by mutual giving and taking that he can grow and improve. In the same way decay and degeneration are avoided or modified.

When a man has learned that mutual obligation is the rule of life, he has acquired controlling power over his actions and will be most careful to act with impartiality and consider that all his acts, however different in kind soever they may be, are of equal value in enabling him to pursue a definite course for a definite result. When a general commands an army the drummer-boy, in his right place, is as necessary to victory or to a well managed retreat as the artilleryman in his. There must, therefore, be concord among all classes, or disaster will follow. If then this be necessary for actions and effects external to ourselves, it is still more necessary when we consider actions or thoughts which originate in our own minds and influence our conduct towards others: this is self-control, and its perfection has been demonstrated to be love for our neighbour.

Man, then, the highest form of creation, is placed in relation with a variety of beings—his inferiors, his equals, and his superiors, towards all of whom he owes different duties. From his inferiors, the beasts of the field, he may learn wisdom, gentleness, patience, perseverance, fortitude, attention, and temperance; all these qualities of character enable him to bear up against adversity, which often overtakes him in his more exalted position, and to which both he and they have to submit. These inferiors are ready to serve and be useful to him, but they require good habitations, food, stored through the foresight of that superior organization with which he is endowed, and kind, gentle, protective treatment. There is no squabble between them of labour and wages—the first is willingly accorded and the wages are plenty of food, considerate treatment and sufficient rest from labour. Such servants will serve and obey him to the death but they resent abuse, and they are not responsible for the effects of their violence because self-control cannot be conveyed to them in their language (if they have one).

His equals are the several grades of his own species, they require precisely the same treatment as the former class, but still greater consideration because they are capable of understanding his language and are able to participate in his intellectual employments and enjoyments. The union between them is of the same kind as in the former but of a stronger and more intelligent character, it allows for failings and omissions of duty, each has faith in the other's conduct, hope in success, and charity in all things.

His superiors are those who have preceded him and who whilst they were alive on earth, exhibited wise moderation and governing power in all matters relating to morality and self-control; they left their brilliant examples for him to follow, having set before themselves from the first the necessity of homage to a Superior Power which they earnestly strove to comprehend, and which claimed their unceasing thought through life.

What may happen to the spirit when it has ceased to exhibit itself, to those with whom it associated on earth in its earthly garb, we have no certain knowledge. But, recollecting that nature, for several thousands of years in the past, has been satisfied with the present product, man, and as at present there seems to be no likelihood of a higher development, the logical outcome of our present condition is, that as the spirit of love which animates man in his earthly tenement cannot die, therefore when an individual ceases to give vocal or other expression of that spirit, it is because further perfection in this present form is unattainable; the body is no longer of any use, it becomes changed into its original elements, but the spirit joins itself unto a mass of similar quality which may be hovering around us, or may be transplanted elsewhere.

If, then, we desire to preserve our bodies, in any condition of life in which we may be placed or to which our intellect may lead us, we best do this and with greatest ease to ourselves by assisting our neighbour, for in benefiting him we indirectly benefit ourselves not corporeally only but mentally also. The benefit is not always apparent but the mind becomes accustomed to the discipline. By this discipline we increase the power for good towards and within ourselves. This produces satisfaction, ease, contentment or happiness of mind. It is purely mental, and reacts upon the body; it may be likened to oil in machinery. The vessel may be tossed by storms but the steadiness and ease with which the machinery works under the lubricating influence lands the vessel safe in the harbour.

But the man who exercises no control over his instincts very soon clouds his understanding and dwarfs his intellectual power; he becomes intemperate and abuses his privilege of manhood. By universal consent such abuse is deemed to be contrary to nature and is termed immorality or vice.

He who, therefore, has not been brought up in, what the cultured portion of mankind considers to be, virtuous principles, that is the knowledge of morality and immorality, or in other words the control of natural appetites, follows those appetites, not because they are vicious but because he does not know or has not learned to appreciate the opposite condition of, that which the majority of mankind calls, virtue. In following unrestrained inclinations he does not perceive that he is acting contrary to his own interests; when, however, he has learned to restrain or control his purely selfish desires he benefits mankind as well as himself and makes life endurable to some whilst the happiness of others is increased. Hence, the difference between happiness and unhappiness is in the exercise of discipline over the passions; this control or discipline should begin at birth and be carefully superintended by the Mother long after the early years of childhood, and if possible beyond the age of puberty; for when our little ones go from under a Mother's guidance, they still stand in need of benevolent supervision to consolidate those principles in which they have been brought up. Time then we see is, also, a factor in the establishment of those principles which influence character; hence, our original aphorism inculcates the necessity of constant watchfulness and control over habits, actions and thoughts for—The Future is Now.

ADDENDA.

I.

TEMPERATURE.

ACCUMULATED masses of snow and ice tend to lower summer temperature in three separate ways—

First, by direct radiation. Snow and ice, however intense the sun's rays may be, tend by direct radiation to lower the temperature of all surrounding bodies to freezing point, *i.e.* 32° Fahrenheit. Perfectly dry air is nearly incapable of absorbing radiant heat, and air when cooled by contact with a snow-clad ground is not heated by the radiation from the sun. Air, however, charged with aqueous vapour is a good absorbent of radiated heat. Snow and ice, when the sun is shining, cool the air by radiation more rapidly than the air is heated by the sun. Hence Greenland's summers seldom rise above 32° F., and pitch on the side of a merchant vessel in this region will melt whilst the air may be below the freezing point. Greenland's summers are colder than our winters because the sun's rays are not absorbed.

Secondly, by reflection. Snow and ice reflect heat-rays, so that the sun's rays falling upon snow and ice are to a great extent reflected back into space, but some rays are absorbed and disappear in the mechanical work of melting the ice, yet the temperature is not raised. The latent heat of ice is about 142° F. One pound of ice when melted takes up heat to raise one pound of water 142° F. This quantity of heat is consumed in tearing the molecules separate and against the forces of cohesion, binding them together in the solid form.

Thirdly, by fog-clouds. The sun's rays in summer-time produce increased evaporation and the atmosphere becomes laden with moisture. But snow-clad mountains or an icy sea, or both combined, by chilling the atmosphere condense this vapour into thick fogs. These fog-clouds prevent the sun's rays reaching the earth, and snow remains unmelted in summer. The coldness of the summer in polar regions is due solely to this cause, for the temperature of a place, other things being equal, is proportionate to the quantity of heat received from the sun.

The chief cause of the secular changes of climate is deflection of ocean currents. This is brought about by the accumulations of ice and snow in winter when one hemisphere is in aphelion: these accumulations lower summer temperature: fogs cut off the sun's rays and retard the melting of snow, and in this way a state of glaciation is brought about. Exactly opposite effects take place in the other hemisphere when the winter is in perihelion.

The trade winds, due to a constant flow of air from the pole to the equator, also assist in this deflection of ocean currents. The strength of these winds depends upon the difference of temperature that may exist between the equator and the higher latitudes. The trade winds of the colder hemisphere will be stronger than those of the warmer, and the median line between the trades will be at a considerable distance north or south of the equator. At present the south-east trade winds are stronger than the north-east trade winds, and make their influence felt as far as 10° or 15° north of the equator, because the southern hemisphere is colder than the northern owing to the greater accumulation of ice and snow at the southern pole. The north-east trade winds at the present time seldom go south of the equator.

The south-east trade winds, then, blowing strongly across the equator, impel warm tropical water into the Northern Ocean and so shift the equatorial currents of the globe northwards. There is besides a strong under-current from the south which impels the Gulf Stream northwards, and a strong upper current of warm air to the south, carrying with it aqueous vapour which will increase snow and ice, so that nearness of the sun to the earth causes an accumulation of ice and is as essential to the production of the glacial epoch as his distance in winter, for heat to produce evaporation is as necessary as cold to produce condensation. The schoolboy's experiment of making ice with snow and salt before the kitchen fire illustrates this point. Therefore, if we should have a high eccentricity on one of the hemispheres, a long and cold winter will be the result. These various causes act and react on each other.

The mean annual temperature of the ocean is greater than that of the land, whether equatorial, temperate, or polar.

First, because the ground stores heat by slow conduction. Water by its mobility and transparency for heat-rays becomes heated to a considerable depth rapidly. Hence heat stored in the ground is small, but heat stored in water is greater in quantity.

Secondly, because the air, probably, is heated more rapidly by contact with the ground than from the ocean. But air is heated by radiation more rapidly from the ocean than from the land. The aqueous vapour of air is diathermanous to radiation from the ground, while it absorbs rays from the ocean and becomes heated.

Thirdly, because air radiates back its heat, and the ocean absorbs heat more rapidly than the ground. The ocean absorbs heat from the aqueous vapour of the air but does not reflect it. On the other hand, the ground whilst it reflects heat does not absorb heat from aqueous vapour. Radiation from air, therefore, tends to heat the ocean more rapidly than it does the land.

Fourthly, the aqueous vapour of air acts as a screen to prevent the loss of heat by radiation from water, while it allows radiation from the ground to pass more freely into space. The sea has greater difficulty in getting rid of heat received from the sun than the land, because the land loses heat more rapidly than the sea. Hence the ocean's temperature is higher than that of land. See Croll on "Climate and Time," and Dr. Maury's "Physical Geography of the Sea."

II.

DEEP-SEA LIFE AND CONDITIONS.

Since the origin of all life, whether vegetable or animal, is more or less connected with water, a general account of the conditions of animal life and strata found at the bottom of the ocean, will be read with interest.*

Round all sea-boards there are found four zones.

The "Littoral" zone embraces the space between two tide-marks; Seaweeds, Crustaceans and Mollusks are here found.

The "Laminarian" zone extends from low water-mark to fifteen fathoms. In this section for the first few fathoms are found Tangles, and in deeper water Scarlet Weeds. There is plenty of vegetable food and the characteristic fauna are Mollusks.

The "Coralline" zone extends from 15 up to 50 fathoms. The fauna are the larger Crustaceans and Echinoderms; also Cod, Turbot, Haddock and Sole, which latter also thrives in fresh water.

The "Deep Sea Coral" zone extends from 50 fathoms to an unknown limit. The number of peculiar creatures in this zone is few.

Life diffuses itself in the direction of least resistance, or in comparative uniform conditions. Hence the conditions affecting animal life at the bottom of the sea will be pressure, temperature and the absence of light, which apparently involves the absence of vegetable food.

The area of the ocean is 139,400,000 miles square.

* See "The Cruise of the *Challenger*," 2 vols.

There is no reason to suppose that the depth anywhere exceeds 5000 fathoms, and if a varied fauna is found at half that depth, it is probable that a similar fauna may be found at an additional depth of 1000 fathoms.*

The average Depth of the sea is 2000 fathoms, and a vast portion is not 1500 fathoms. The mean average depth of the Atlantic Ocean is a little over 2000 fathoms. The basin of the China Sea has a mean depth of 1200 fathoms, with a uniform temperature of 36° F., the bottom being formed of a pale grey ooze. The deepest successful sounding in this sea was taken in Lat. 11° 24′ N., Long. 143° 16′ E., where a depth of 4475 fathoms was obtained : the bottom was found to be volcanic sand with manganese. At this depth the majority of the thermometers were crushed, due to the pressure of five tons to the square inch. The temperature was 33·9° F., the surface temperature being 80° F.

The Pressure at the depth of one mile is equal to 159 atmospheres. At 1000 fathoms it is equal to 200 atmospheres; at such a depth an animal sustains a weight of one ton to each square inch of surface; at 3000 fathoms it sustains a weight of three tons. Sharks living at 300 or 400 fathoms are subject to a pressure of 1120 pounds on the square inch; and Mollusks and Annelides brought up from 1000 fathoms are either dead or sluggish.

Air, it is well known, is highly compressible, but water only to a slight degree ; hence it is probable that under a pressure of two hundred atmospheres water may become more aërated and in that respect more capable

* One Mile or 1760 yards equals 880 fathoms.
Two Miles or 3520 „ „ 1760 „
Five Miles or 8800 „ „ 4400 „

of supporting life in deep sea than near the surface. Elasticity in the ocean is not in ratio to the pressure; it is regular up to 1000 fathoms, but down to 2000 fathoms it decreases in compound ratio, when it nearly ceases.

The average Temperature at sea bottom is 0° C., and at any depth does not sink below −3·5° C. This is not inconsistent with animal life. The temperature of the Telegraphic Plateau of the Atlantic is from 2° C. to 3° C., *i.e.* 35° F. to 37° F. In the Bay of Biscay at 2500 fathoms the temperature is 35° F.

There is no universal temperature, but owing to currents both hot and cold water is found at all depths, and Mollusks are more abundant and varied in warm than cold areas.

Sea water increases in density up to its freezing point and does not show the peculiarity of fresh water, which attains its maximum density at 39° F. Hence, two ocean areas with different (climates) bottom-temperatures due to currents may be in close proximity. This has considerable bearing upon the marine distribution of life and the interpretation of palæontological data. The *Challenger* when cruising off the Faroe Islands discovered two areas—one *cold* where the bottom was rough and gravelly, the other *warm* where the bottom consisted of globigerina ooze. In these two areas were found many deep-sea animals believed to be extinct but identical with the fossils of the Tertiary Period, and other specimens which, besides being associated with these extinct fauna, illustrated more recent periods—just as the vitreous sponges illustrate the ventriculites of the chalk.

For 1000 fathoms downwards water loses its temperature uniformly at the rate of 5° F. for every 250 fathoms. For the first 100 fathoms loss of temperature is rapid, down to 600 fathoms only slowly, and extremely slowly to the bottom. In the Mediterranean Sea whatever the temperature may be at 100 fathoms, *i.e.* about 13° C. or 55° F., the same temperature is found in the whole mass beneath; so that in this sea a depth of 1400 fathoms has a uniform and moderate temperature.

In many animals living in deep seas there is an entire absence of eyes, but in others a full development of them; at present this is unaccounted for. In certain cases it is possible that when the sun's light is diminished the power of vision in some animals becomes more acute, and the eye may become susceptible to the stimulus of phosphorescence.* Solar rays do not become totally extinguished until they have reached 150 fathoms.† By the deep-sea photometer Sir Wm. Siemens showed that sunlight at 25 fathoms blackened paper; at 50 fathoms it browned paper; at 75 fathoms stained paper yellow; and at 100 fathoms faintly tinged it after five minutes' exposure; but light in even measurable quantities will descend to a greater depth to exert its influence on animal and vegetable life.‡ The electric light is said to be visible at a depth of 99 feet under water.

Plants are barely represented below the first 50 fathoms, and are entirely absent at a depth of 200 fathoms. Vegetation therefore seems to be limited to depths under 200 fathoms. The distinction between

* "Living Lights, a popular account of Phosphorescent Animals and Vegetables," by C. F. Holder. 1887.

† "The Atmosphere," by C. Flammarion.

‡ "Life of Sir W. Siemens."

plants and animals is that the former prepare food for the latter by decomposing certain inorganic substances, which animals cannot use as food, and by recombining their elements into organic compounds upon which animals can feed; so far as at present known this process is effected only under the influence of light.

The bottom of the sea, as ascertained by the cruise of the *Challenger*, seems to be one mass of animal life; at 600 fathoms there is abundance of animal life including some few bony fishes. The means of subsistence for this animal life doubtless is furnished by the organic compounds fabricated by plants at considerable depths as well as by other organic matters which descend from the surface to the bottom.

Near Cape St. Vincent, at a depth of 2090 fathoms, a Pleurotoma was obtained which had a pair of well-developed eyes on short foot-stalks. As light at this depth can scarcely be from the sun it may be due to phosphorescence. Among the larvæ and young of deep-sea animals phosphorescence is very general.

In connection with sea phosphorescence I witnessed a striking phenomenon in the Arabian Sea, about 300 miles from the island of Socotra on the 12th of January, 1880. Temperature 82° F. About 8 p.m. we suddenly entered a phosphorescent area of some 90 miles in diameter. The sea as far as the horizon was one blaze of light illuminating the sky, enabling one to read if so disposed. We seemed to be in a sea of milk. Floating near the surface were phosphorescent Medusæ, Girdles of Venus and other animals, whilst far below monsters of the deep in varied forms and size were distinctly visible from the deck of H.M.S. *Tyne*. This condition lasted till 4 a.m. the 13th of January, and disappeared as suddenly as it began. A less brilliant appearance was noted on the evening of the 13th, when the temperature was 79° F., but it did not last quite two hours.

The Fauna of deep water are confined to two belts, one near the surface and one near the bottom, with an intermediate zone in which the larger Vertebrates and Invertebrates are absent. Depths beyond 500 fathoms throughout the world are inhabited by the same fauna.

Radiolarians are found throughout the whole of the Atlantic Ocean, and pelagic Foraminifera universally throughout the temperate and warmer seas. Sponges are found at all depths, their maximum development being between 500 and 1000 fathoms. The Holotherideæ are generally found at the greatest depths.

Abyssal Mollusks are not devoid of colour, but they are paler than those from shallower waters; neither are they universally destitute of eyes, but there is a great tendency to dwarfing both in this and other classes at great depths.

Abyssal Fauna are more associated with the fauna of the Secondary and Tertiary Periods than shallower water fauna; but in high northern and southern latitudes they resemble those of shallower waters because the conditions of temperature are similar.

The conditions, therefore, at the bottom of the sea at all depths are such as admit of the existence of animal life and also of the unlimited extension of animals high in the zoological series in relation with the fauna of shallower zones.

The Bed of the Atlantic Ocean at present is of modern chalk. Modern chalk differs from ancient white chalk in the presence of free silica. Recent Atlantic chalk-mud abounds in inorganic silica or sand—from 30 to 40 per cent.; its origin is due to the direction of currents. In chalk-mud the silica exists as spicules of Sponges, spicules and shields of Radiolarians and the frustules of Diatomeæ. The extreme purity of the Sussex white chalk indicates that it was laid down in deep water far from land.

Ancient white chalk is made up mainly of the debris of Foraminiferæ—one million to a cubic inch. With the absence of diffused silica in pure white chalk there are regular layers of flints, which are masses of nearly pure silica, bearing the external form of sponges and filling-up of sea-urchins and bivalve shells. Silica has percolated in solution or in a gelatinous condition, *i.e.* the organic silica has been reduced to a colloid condition and accumulated in moulds formed by shells or the outer walls of imbedded animals of various classes; it is not known how this solution was effected.

European Tertiaris with the exception of some older beds in Southern Europe have all been deposited in shallow water, so that these beds represent mineral accumulations and fauna of the margin of some sea. Tertiaris may be regarded as deposits formed and exposed by the depressions and upheavals of the borders of the Cretaceous Sea which existed continuously. The modern chalk is the lineal descendant of the ancient chalk and remains in possession of the ancestral estate. Hence, the bathymetrical range of the various groups in modern seas corresponds with the vertical range in ancient strata.

The Atlantic Ocean covers 30 million square miles;

its bottom is formed of calcareous deposits—Globigerina Ooze, pelagic Foraminifera, broken and decomposed shells of the genera Globigerina, Orbicularia, Pulvinulina, Pullina and Sphæroidinia—these are chiefly concerned in forming the modern chalk; these genera instead of living at the bottom of the sea inhabit the surface and the water to a limited depth beneath. At a depth of 2300 fathoms globigerina ooze seems to cease and to be replaced below that depth by red clay from 2740 up to 3025 fathoms.

Over large beds of the ocean pumice is found in different stages of decay, near volcanic centres and sometimes at great distances from them. This volcanic matter in fine subdivision consists mainly of minute particles of feldspar, magnetite and other minerals, and is especially evident in the Red Clay area. Hence Red Clay is probably derived in great part from the decomposition of volcanic products. The Red Clay found spread over the Atlantic bed is not an additional substance from without, occupying certain depressed regions, but has been uncovered by the removal of carbonate of lime (which constitutes 90 per cent. of Globigerina Ooze) by some means or other—possibly chemical.

Nodules of peroxide of manganese are abundant in the red clay; also silex spicules from the tests of Radiolarians and calcareous tests from Foraminifera. These latter are not so numerous as the former, but both exist; and the varying amounts of each alter the character of red clay. A considerable portion of fine molecular matter of which red clay is composed is insoluble residue, the ash of calcareous organisms from globigerina ooze; in all animal tissues inorganic salts exist, and during the decomposition of animal tissues in contact with sea-water these salts pass into more stable constituents.

Free Coral Sand consists almost exclusively of carbonate of lime in a fine ultimate subdivision in consequence of having entered into the structure of the skeletons of animals through the vital powers. It is easily soluble in water containing carbonic acid. There is always a certain amount of carbonic acid dissolved in rain, and this falling upon coral sand sinks in and renders it soluble by converting it into bicarbonate of lime, this soluble carbonate of lime acts then as a cement uniting the grains of sand before the carbonic acid is dissipated; in this way successive layers give a character of stratification and lamination.

In Bermuda the rock thus formed is white granular limestone; it is hard and used for building purposes. Great denudation however is constantly going on to form sand-hills. These terminate landwards in a regular glacis; as the sand advances layer after layer is added. At Elbow Bay there is a sand-glacier twenty-five feet thick which progresses regularly inland and overwhelms everything in its advance. The cause is unknown unless effected by wind, as supposed by Mr. Geikie. Oleander trees when planted in time have been found to stay or to turn the advance of the sand and the motion ceases.

Visitors to Grand Canary will also observe a sand-glacier on the road from the pier to Las Palmas, and may note the effect which tall shrubs have had in opposing and turning the advance of the sand.

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