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THE PHILOSOPHY OF NATURAL HISTORY,

BY

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WITH AN

INTRODUCTION

AND

VARIOUS ADDITIONS AND ALTERATIONS,

INTENDED TO ADAPT IT

TO THE PRESENT STATE OF KNOWLEDGE.

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EXTRACT

FROM THE PREFACE TO THE ORIGINAL WORK.

ABOUT fifteen years ago, in a conversation with the late worthy, respectable, and ingenious Lord KAMES, upon the too general neglect of natural knowledge, his Lordship suggested the idea of composing a book on the PHILOSOPHY OF NATURAL HISTORY. In a work of this kind, he proposed that the productions of Nature, which to us are almost infinite, should, instead of being treated of individually, be arranged under general heads; that, in each of these divisions, the known facts, as well as reasonings, should be collected and methodised in the form of regular discourses; that as few technical terms as possible should be employed; and that all the useful and amusing views arising from the different subjects should be exhibited in such a manner as to convey both pleasure and information.

This task his Lordship was pleased to think me not altogether unqualified to attempt. The idea struck me. I thought that a work of this kind, if executed even with moderate abilities, might excite a taste for examining the various objects which every where solicit our attention. A habit of observation refines our feelings. It is a source of interesting amusement, prevents idle or vicious propensities, and exalts the mind to a love of virtue and of rational entertainment. I likewise reflected, that men of learning often betray an ignorance on the most common subjects of Natural History, which it is painful to remark.

I have been occasionally employed, since the period which I have mentioned, in collecting and digesting materials from the most authentic sources. These materials I have interspersed with such observations, reflections, and reasonings, as occurred to me from considering the multifarious subjects of which I have ventured to treat. I knew that a deliberate perusal of the numerous writers from Aristotle downwards, would require a considerable portion of time. But the avocations of business, and the translating of a work so voluminous as the *Natural History of the* COUNT DE BUFFON, rendered my progress much slower than I wished. I now, however, with much diffidence, submit my labours to public opinion.

With regard to the manner of writing, it is perhaps impossible for a North Briton, in a work of any extent, to avoid what are called *Scotticisms.* But I have endeavoured to be every where perspicuous, and to shun every sentiment or expression which might have a tendency to injure the feelings of individuals.

Indulgent readers, though they must perceive errors and imperfections, will naturally make some allowance for the variety of research, and the labour of condensing so much matter into so small a compass. He is a bad author, it has been said, who affords neither an aphorism nor a motto.

Upon the whole, the general design of this publication is, to convey to the minds of youth, and of such as may have paid little attention to the study of Nature, a species of knowledge which it is not difficult to acquire. This knowledge will be a perpetual and inexhaustible source of many pleasures; it will afford innocent and virtuous amusement, and will occupy agreeably the leisure or vacant hours of life.

ADVERTISEMENT RESPECTING THIS EDITION.

In preparing this edition of Smellie's Philosophy of Natural History, I have endeavoured to avail myself of such modern discoveries and improvements in Physiology and Natural History as are connected with the subjects of which the book treats. It will be observed that instead of the two first chapters of the original work, I have substituted an Introduction, containing some very general views of animal and vegetable life, and a brief sketch of the structure and classification of the whole animal kingdom. That something of this kind was rendered necessary on account of the great light thrown upon these subjects by the progress recently made in Comparative Anatomy, cannot be doubted; and it was found easier to compose these chapters entirely anew, than to incorporate the requisite additions with them as they originally stood.

With regard to the remainder of the work, although a good deal has been added or rewritten, yet it has upon the whole been made considerably shorter, by the omission of many passages, which did not seem of sufficient importance to be retained; and also by the omission of many passages and a few chapters which touch upon subjects interesting only to the scientific reader, and which were deemed unnecessary in an edition intended for general use.

Some apology may perhaps be required for the freedom with which these alterations have been made in a standard work of so great merit. On this subject it can only be said, that there was no other method by which it could be adapted to the use of young persons learning the elements of Natural History. Many of the views contained in the original edition have been since proved unfounded, and these it was necessary to correct. In many parts of it are details of great length, and often irrelevant to the subject, which it was thought proper to abridge or exclude; and I trust that, upon a fair comparison of it with this edition, I shall appear to have taken no greater liberties than were necessary to fit it for the purpose for which it is principally intended—the instruction of the young.

The whole Introduction, as was observed above, has been prepared by the editor, with the exception of a few passages, distinguished by inverted commas, which are retained from the original work. In the body of the book, those passages which have been added, or which have been entirely remodelled or rewritten, are distinguished by *single* inverted commas; quotations from other authors being marked in the usual way by *double* inverted commas.

Boston, Jan. 1824. J. W.

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* This and the preceding Chapter having both been inadvertently numbered XI, the subsequent Chapters continue the series from this number, as well in the body of the work as in the Analytical Table of Contents.

N. B. The following are such errata as have been observed, affecting the sense of the passages where they occur.

Page 15, last line but one in the note, *for* reviving *read* renewing.
49, sixth line from the top, " stag " hog.
162, seventeenth line from the top " of two " or two.

On pages 87 and 88 the *double* inverted commas should be *single*.

THE PHILOSOPHY OF NATURAL HISTORY.

INTRODUCTION.

CHAPTER I.

OF THE NATURE OF LIVING BODIES, AND THE DISTINCTION BETWEEN ANIMALS AND VEGETABLES.

THE most superficial observers are in the habit of remarking certain great and striking differences in the nature, structure, and qualities of the objects around them. They perceive at once, that a stone is something very different from a plant, and a plant something very different from an animal, although they do not task themselves to determine exactly in what this difference consists. It is natural as well as convenient, for mankind to class things together according to their most obvious characteristics, and in this way we have come into the use of a certain arrangement of natural bodies, not founded upon a knowledge of their intimate nature and essential qualities, but upon those which produce the most lively impression on our senses after only a slight examination. Thus have been established the *mineral*, *vegetable*, and *animal* kingdoms, which include under them all the objects of the material world.

It is obvious that this arrangement is founded upon an examination of those objects only, which are most within our immediate observation, and with whose qualities and properties we have been most familiar. We see that rocks and mountains are immoveably fixed to the same spot and remain always of the same size; that the earth does not change its surface except by the operation of violent and unusual causes. Plants, on the contrary, are undergoing constant and spontaneous changes; some are dying and decaying, others sprouting up from the earth, coming forth, as it were, from a new creation, giving birth to a new set of individuals like themselves, and sinking in their turn to decay. Further still, we see animals, not only coming into existence, living, growing, and giving origin to other animals, but exercising various other offices, —feeling, moving, uttering sounds, suffering and enjoying, establishing a thousand connexions with things and beings about them, which contribute to the support or happiness of their existence. In this way we have come to the division of created things into the three classes above mentioned. It is sufficient and convenient for the popular purposes to which it has been usually applied, but it is evident, if we but examine it, that it is not strictly and scientifically correct.

A more accurate and philosophical division of natural objects is into such as *are possessed of life* and such as *are not possessed of life*. This throws animals and vegetables into one class, and all mineral substances into the other; for there is a much more close and intimate relation between the two former, than there is between either of them and the latter. They have many circumstances of analogy with one another in respect to their structure and functions, in which they do not at all resemble any object or operation of the mineral kingdom. These two classes then include all the various bodies which compose the world around us, and those belonging to each are distinguished, as possessing certain general properties and being governed by certain general laws, common, in a greater or less degree, to all of the same class.

In the first place, living bodies are distinguished from other substances in the mode of their origin; they are always produced by other preceding individuals similar to themselves; they are always the offspring of parents. This is an obvious and complete distinction. No mineral substance, no substance not possessed of life, is ever brought into existence in this way. It is true that new bodies in the mineral world are sometimes formed by the accidental aggregation of particles, or by the spontaneous combinations which are occasionally the result of chemical laws, but this is something clearly very different from the mode of production which takes place in living bodies. One stone does not produce another like itself, a crystal does not produce a crystal, nor one grain of sand another. There is nothing like the relation of parent and offspring.

In the second place, living bodies differ as to the mode of their existence, in so much as they are dependant upon other things beside themselves for the continuance of that existence. The matter of which they are composed, is constantly changing. This matter is in fact only common matter endowed for a certain period with the powers of life, in consequence of being united to living systems. By the various internal operations constantly going on, part of this matter is expended, is sent out of the system; this loss must be repaired by the addition of new matter. Hence the necessity of nourishment to the support of life; hence the necessity of a regular supply, to every thing living, of a certain quantity of food adapted in kind to the nature of the individual. This food is operated upon by the organs of the animal or vegetable, is assimilated to it, and its properties are modified until it becomes fit to make a component part of it. This is *nutrition*, an essential process of living bodies, by which they are enabled to increase in size and strength, to modify the structure of their different parts, and to maintain them in a fit state for performing the offices for which they are designed. Minerals, on the contrary, have no such dependance; they are sufficient for themselves; the matter of which they consist is always the same; they contain within themselves every thing which is essential to their existence, and have, of course, no necessity for nutrition or growth. It is true that these substances sometimes increase in size, as happens with regard to stalactites, the deposition of crystals, and the formation of alluvia. But there is this marked difference between all such instances of growth, and that of animals or vegetables; that, in the former case, it amounts to the mere juxtaposition of similar particles, unchanged in their nature; whilst in the latter the particles are changed in their nature and subjected to the operation of entirely new laws. In the former case the growth depends upon a principle operating from without; in the latter upon a principle operating from within.

But, in the third place, though dependant upon other substances in this way for the means of continuing their existence, living bodies possess in another point of view a kind of independence upon all other matter. They are removed, by the possession of the powers of life, in a certain degree out of the influence of physical and chemical laws; they contain within themselves a principle by which they are enabled directly to resist the operation of those laws, which would otherwise ensure their speedy destruction. They depend upon the things around them for the materials of their support, but the power of altering the nature of those materials and appropriating them to their own use is peculiar to themselves. The functions of living systems are not only performed without the assistance of the physical powers of matter, but often in direct opposition to them; and the substances which are introduced into them, lose their chemical relations, and are combined according to new laws, and for new purposes.

This power of *insulation*, possessed by living systems, is in no instance more strikingly evinced, than in the possession by animals of a certain degree of vital heat, which they preserve under all circumstances, short of those which impair or destroy the texture of their parts. This degree of heat—which in man is about 98° of Fahrenheit's thermometer—continues nearly the same, even when we are exposed to the most intense cold, and is but little elevated when we are subjected to a heat above that of boiling water. In many countries, in which the degree of cold is for many months in the year very much below the freezing point of mercury, men not only exist, but enjoy all the comforts of life. In some high latitudes, Europeans have been exposed to temperatures as low as −50° or even −60° of Fahrenheit's thermometer, that is, to a cold 150° below the natural standard of animal heat, and have escaped every ill consequence. Very lately the whole of two ships' crews wintered in about 75° of north latitude in perfect safety, where the temperature of the air was, for many weeks together, almost constantly below −30°, and where they became so accustomed to severe cold, that the atmosphere, when at zero, felt mild and comfortable. On the other hand, in many countries men exist without difficulty under a high degree of heat. In Sicily, during certain winds, the thermometer has been observed at 112°, in South America by Humboldt at 115°, in Africa at 125°. But, for a limited period, much higher degrees of artificial heat have been borne without injury. Individuals have exposed themselves voluntarily to the air of ovens at temperatures from 260° to 315° of Fahrenheit's thermometer, without any very great inconvenience, while water was boiling and meat baking in the same atmosphere. These facts show a power of resisting the operation of external causes which is possessed by no substances except such as are endowed with life, and is, probably, possessed in some degree by all that are. For, although vegetables and the lower orders of animals are not capable of resisting to the same extent the influence of heat and cold, yet they all show in some measure the existence of the same power. And in the most imperfect species, where there is no other evidence, this power is evinced by the fact, that the individual freezes with greater difficulty before than after death, other circumstances being equal.*

Another illustration of the same principle is derived from the change which takes place in the body after death. With this change we are all familiar. No sooner has it taken place, than the heat and moisture of the external air commence the work of destruction. The skin is discoloured, it becomes green and livid, the eyes sink in their sockets, the flesh becomes soft and putrid, it falls from the bones and is converted partly into fœtid exhalations, and turns partly into dust. Even the bones finally yield and lose their form and consistency. Now why should this happen more readily after than before death? The composition of the body is the same, and it is exposed to the same moisture and heat. It happens because the life has departed which gave to the body a power of resisting the operation of these causes.

This suggests to us, in the fourth place, another distinction of living substances, viz. that they all terminate their existence in death. By this event, the materials which entered into their composition are deprived of the bond which held them together and gave to them their peculiar form, viz. the principle of life. They therefore separate, and retain only those properties which they possessed before becoming parts of a living system. Dust returns to dust, earth to earth. It is true that some of the parts of living bodies, both animals and vegetables, do not, very readily, undergo the process of decay. The bones, teeth, shells, and horns of animals; the trunks, branches, and roots of trees retain for an almost indefinite length of time, under certain circumstances, their shape and substance. This circumstance,

* In quadrupeds and birds the animal heat is generally greater than that of the surrounding atmosphere, whilst in other animals of the inferior classes, it is seldom very different from that of the objects around them. The former are called warm-blooded and the latter cold-blooded. In the former, the temperature is capable of but slight variation, from external causes; in the latter its range is pretty extensive, and it varies a great number of degrees. The temperature of a man plunged into cold salt water at 44°, has been known to sink to 83°, and, when exposed to a heated atmosphere, to rise to 100°; in other animals similar varieties have been observed. But the temperature of the viper, a cold-blooded animal, when exposed to a heat of 108°, rises to 92°, and when exposed to a cold of 10° sinks to about the freezing point of water, showing at once an extensive range of temperature within which the functions can go on, and at the same time a decided power of resistance against any further alteration.

Eggs possess an analogous power. A new laid egg and one which has been frozen and thawed, being exposed in a freezing mixture together, the former will be some minutes longer in freezing than the latter. This has been ascertained by experiment. The same is true of the lower orders of animals and vegetables.

however, is owing not to their continuing to possess life itself, but to the particular nature and composition of the texture of which they are composed. Nothing like this takes place in other substances; they can be destroyed only by the action of some mechanical agent which separates their parts, or by that of some chemical one, which alters their combinations.

These are circumstances of distinction common to all living bodies, whether animal or vegetable. But another subject of inquiry is, how are these to be distinguished from each other? Although it may seem very easy to distinguish an animal from a vegetable; yet the true principle of distinction eludes investigation. Many philosophers have attempted to define wherein it consists, but have failed in the attempt. There is generally little practical difficulty in determining whether any particular substance belong to the animal or vegetable kingdom, and yet so nearly do the lower species of animals resemble plants in the functions they perform, that it is almost impossible to point out what constitutes the real difference between them.

Some writers, among whom is the celebrated Buffon, have believed that there is in fact no exact boundary between the animal and vegetable kingdoms, that they run into each other at their extremities, and form so regular a gradation from the one to the other, that no precise dividing line can be drawn between them. But although there is this apparent confusion at the boundaries of the two kingdoms, yet, generally speaking, animals are distinguished from plants by their composition, their structure, their mode of life, &c. And although with respect to each particular circumstance there may be particular exceptions, yet taking the whole together we get a good general idea of an animal as distinguished from a plant. Thus the power of locomotion, or of motion from place to place, has been considered as peculiar to animals, and in a general way it is so; yet there are many exceptions. Oysters, the sea anemone, corals and corallines, now known to be of an animal nature, "can hardly be said to enjoy the power of local motion. Many species remain fixed to the rocks on which they were produced, and have no motion but that of extending and contracting their bodies." And, on the other hand, some species of plants are not fixed by roots to one and the same spot, but float about in the sea, receiving nourishment from its waters.

The power of moving some part of themselves by an internal principle has also been believed peculiar to animals. It is not so. Many plants are possessed of the faculty not only of motion of this kind, but of moving as if with some definite purpose. "The sensitive plant possesses it in an eminent degree. The slightest touch makes its leaves suddenly shrink, and together with the branch bend down towards the earth. But the moving plant, or Hedysarum gyrans, furnishes the most astonishing example of vegetable motion. It is a native of the East Indies. Its movements are not excited by the contact of external bodies, but solely by the influence of the sun's rays*. Its motions are confined to the leaves, which are supported by long flexible foot-stalks. When the sun shines, the leaves move briskly in every direction. Their general motion, however, is upward and downward. But they not unfrequently turn almost round; and then, their foot-stalks are evidently twisted. These motions go on incessantly, as long as the heat of the sun continues. But they cease during the night, and when the weather is cold and cloudy. The Dionæa muscipula, or Venus' flytrap, a plant of Carolina, affords another instance of rapid vegetable motion. Its leaves are jointed, and furnished with two rows of strong prickles. Their surfaces are covered with a number of minute glands, which secrete a sweet liquor, and allure the approach of flies. When these parts are touched by the legs of a fly, the two lobes of the leaf instantly rise up, the rows of prickles lock themselves fast together, and squeeze the unwary animal to death. If a straw or a pin be introduced between the lobes, the same motions are excited."

The common barberry (Berberis vulgaris) is another instance to the same effect. When its flower is fully expanded, if the inside of one of the filaments of its stamens be just touched by a pin or a straw it contracts instantly and throws its anther forward with some force against the stigma.

"When a seed is sown in a reversed position, the young root turns downward to enter the earth, and the stem bends upward into the air. Confine a young stem to an inclined position, and its extremity will soon assume its former perpendicular direction". The roots of a tree growing on dry or barren ground in the neighbourhood of that which is moist or fertile, become larger, longer, and more full, in that direction, than in any other, as if extending themselves to obtain the nourishment which can there be afforded them. If we twist the branch of a tree so that the under surface of the leaves

* Sir J. E. Smith asserts that light is not necessary, but that only a warm still atmosphere is required to produce this phenomenon in perfection.

shall come uppermost, they gradually turn upon their foot-stalk till the proper side is exposed to the rays of the sun. This they will do repeatedly until they have become injured by the exertion, and if the leaf be confined, so that it cannot resume its natural position, its stalk will become twisted by the effort to accomplish it. The sunflower, the leaves of the mallow and some other plants turn generally their faces towards the sun. The tendrils of plants, on the other hand, move always towards the shade, in whatever direction it may be. In a greenhouse, if exposed to the morning light, they direct themselves towards the west, at noon to the north, and at night to the east. They are also attracted by opaque bodies.

Instances of a similar nature are afforded by the sleep of plants, as it has been denominated. The leaves of many plants are folded together during the night, and droop as if dying. In some instances they are so arranged, when in this state, as to serve as a protecting cover to the flowers or young fruit, from the noxious effects of the dew upon them. The flowers of other plants follow the same law and close at the approach of night, for the apparent object of shelter and protection. The modes in which this is done in different cases are exceeding various, but the simple mention of the fact is sufficient for the purpose of illustrating this internal power of motion.

Yet, although we cannot distinctly point out in what this kind of vegetable motion differs from the motions performed by animals, there is no difficulty in perceiving that they are entirely different. Although we see in the vegetable world many instances, where plants exhibit phenomena which seem almost to imply the possession of volition, of sensation, and of thought, yet upon examination of each of these instances, we find ourselves in no danger of confounding the plants, in which they exist, with the animal kingdom. The general aspect, the form, the structure, and the relation of the various parts are entirely different; and it is in their general character that these two classes of created things differ from one another, and not in the possession of any one distinct discriminating principle. Let us look for one moment at the circumstances in which vegetables and animals are distinguished by the possession of different organs, a different structure, and a difference in the principles which actuate them.

1. With respect to their mode of taking and digesting food. In animals this is done by an act of their own, by the exercise of volition. They in some sense exercise choice and make

efforts to get that which is adapted to their purposes. This is obvious enough with regard to the larger and more perfect animals; but even in the most imperfect kinds, as in the polypes, we find that they are capable of sending out their arms or feelers in search of food, which when offered to their grasp, they seize and convey into the organ appropriated for digestion. It is true that the roots and other parts of plants, as has been already remarked, show a sort of intelligence and discrimination in the course which they take in search of moist or fertile ground, and in avoiding or seeking light or shade, which is analogous to the low degree of power manifested in the feelers of the polypes; yet the analogy is but slight, and does not imply the existence of spontaneous and voluntary motion. Animals are affected by the sensation of hunger, and are induced by it to make immediate and voluntary exertions for its relief. Vegetables are not so affected, and the efforts which they make to obtain nutriment are slow, and accomplished as much by the gradual operation of external circumstances, as by an internal and voluntary power.

2. Digestion is performed in animals by means of a stomach and an intestinal canal. The food is taken into the body and is there operated upon by organs, which are different in different species, according to the nature of the substances on which they subsist. The principal of these is a stomach. In plants, on the contrary, nourishment is absorbed directly from the earth by the roots, or from the air by the leaves; there is no intermediate organ where a change is wrought in its nature before it is introduced into the circulation; and, although such a change is gradually wrought, by which it is adapted to the purposes of the particular plant into which it is taken, yet it is not effected, as in animals, by means of their internal surface. For although it has been said, that the polypes, when turned inside out, continue to perform the function of digestion without interruption as under ordinary circumstances, yet even in this case it is still the internal surface which digests, that which was formerly external, exchanging functions as well as situations with that which was within.

3. Animals differ widely from vegetables also in the nature of their food. They are not capable, like plants, of being nourished by the common elements of nature, but require substances which have been already organized, which have already formed a part either of some plant or animal. The polype cannot subsist upon the water in which it floats; it

cannot thrust its feelers into the soil and draw up nourishment from it like the roots of vegetables; no animal can do it. They must have recourse to either animal or vegetable substances which are adapted to their wants and are thrown in their way. The earthworm, it is true, swallows earth for its nutriment, but only that earth which is full of organized matter in a state of decay, and it is only that matter which is digested, whilst the bare earth is evacuated without alteration.

4. Animals differ from vegetables in the time of taking their nourishment. The roots of the latter are constantly exposed to the contact of the substances from which they derive their support, they are always buried in the earth which contains and from which they absorb their food. Their leaves, also, are always spread to the air from which they receive one portion of their support. It is not so with animals; their supplies of food are only occasional. They are stimulated by appetite, at certain definite periods, to seek for the means of gratifying it; after obtaining which they are engaged by other occupations, and are liberated from this care, until an additional supply becomes necessary, and they are excited to obtain it by a fresh appetite.

5. Animals differ again from plants in being possessed of the powers of feeling and voluntary motion. It is true that very remarkable phenomena are exhibited by individuals of the vegetable kingdom, which seem to imply the possession of these powers by them. But examination shows that there is a clear distinction between these instances and those which are afforded by animals. There is no resemblance between the contraction of the leaves of the sensitive plant or the vibratory motions of the Hedysarum gyrans, and the extension of the feelers of the polype or the contraction of the shell of the oyster. The former motions seem to proceed from the actual contact of some substance upon the moving part, or the stimulus of light and heat; the latter, from the spontaneous and voluntary efforts of the animal itself. These differences would be made more obvious by a knowledge of the history of the lower classes of animals. But it may be at present observed, that however remarkable these instances of vegetable motions are, and although they seem as if they might be the result of knowledge, volition, and sensation, they are yet entirely different in nature from the knowledge, volition, and sensation manifested by animals, and do not give cause for confounding these two classes of beings together.

6. The structure and form of vegetables afford also marks of distinction. These are sufficiently familiar without any particular explanation. It is true that there are some marine productions, such as the sponges, corals, &c. having the shape and in some measure the appearance of plants, which are yet without doubt of animal origin. But of these it is to be remarked, that they are not animals themselves, but the residence of animals; they are substances produced by the labour of myriads of little polypes, who pile them up in order to serve for a covering and protection to themselves; and, although when thus produced they have the external shape of vegetables, the creatures themselves, which have produced them, do not bear the smallest resemblance to plants.

7. The chemical composition of vegetables also differs from that of animals. The elements essential to vegetables are three in number, oxygen, carbon, and hydrogen; and from these three principally are formed all the different substances which we meet among plants. But, besides these three, animals require also the presence of azote or nitrogen, which is necessary to their composition; and from this, combined with the others in different proportions, are formed all the parts absolutely essential to animal existence. There are, it is true, many other elements which are found in some parts of plants or animals, but these are all which are absolutely essential to the composition of vegetable or animal substance. Thus in the bark of some plants, beside the three elements necessary to its formation, there will be found a portion of silex or flint; and in the bones of animals, in addition to the four essential elements, lime is deposited in large quantities. So that, although there must always be present at least these necessary and specified elements in the composition of vegetables and animals, there is no limit, no principle which precludes the admission of others.

In consequence of this difference in chemical composition, and perhaps of the mode in which the elements are combined, other differences of a particular character may be detected between substances of a vegetable and those of an animal origin; differences which serve in cases of doubt to assist us in deciding to which class any particular substance belongs. Thus, in burning, substances of animal origin always exhale a very peculiar odour, that of burnt wool, feathers, sponge, &c. an odour easily recognised and not readily forgotten. This will always serve to determine whether any particular substance which we examine is derived from the vegetable or animal kingdom.

Physiologists have frequently busied themselves in endeavouring to discover what it is, which distinguishes precisely the two living kingdoms from each other. They have endeavoured in vain, because they have expected to find this distinction in one single principle which would admit of a short, plain, and specific definition. Such a principle can be only ideal. It does not exist even with regard to the mineral and living classes of substances. It would not be difficult to confound the boundaries of living and dead matter, in the same way as those of vegetable and animal matter. The distinction must be sought in the general structure, the general mode of existence, and the purposes of existence in the two. And in a few words we may say, that animals differ from plants in being furnished with internal organs for the purpose of digesting food, instead of absorbing it by roots from the earth; in being furnished with organs which render them capable of moving from place to place, or at least of moving one part of their bodies on some other part; in having powers of sensation, perception, and volition, by which they acquire a knowledge of the existence and qualities of other bodies besides themselves, and form some sort of relation or connexion with them; and in being obviously intended, by the possession of these organs and powers, to be conscious of and to enjoy existence.

CHAPTER II.

GENERAL REMARKS ON THE STRUCTURE OF VEGETABLES.

In considering plants and animals with a view to the description of their structure and organs, there is one remarkable circumstance worthy of attention at first, viz. that—while the animal kingdom exhibits a great variety between different classes in respect to the perfection, completeness, and complexity of their structure, and the number of their functions; so that a regular series is formed, ascending from the lowest and most imperfect worm possessed of no faculties but those of feeling and moving, up to quadrupeds with all their wonderful and varied powers —the vegetable kingdom on the contrary exhibits but little of this sort of variety. Plants are nearly all alike with regard to the organs they possess and the functions they perform. On the one hand, the polype and the elephant, do not differ from each other more in size, than they do in the number and complexity of their organs, and the extent and perfection of their powers and functions. Whilst, on the other hand, the humblest moss is scarcely less perfect, less complicated, or possessed of less extensive powers, than the most lofty tree. Vegetables vary in their form, their size, their fruit, and many other particulars; but we cannot say of one, that it is of a higher order in the scale of creation than another, as we can of animals. There is no series beginning at an individual of low and obscure powers, and ending in one of powers numerous and elevated.

The structure of plants is exceedingly simple and nearly alike in all the different classes, so far as they have been examined. The important parts, which serve to provide for their nourishment and growth, are the root, the stem, and the leaves. These are all formed of a variety of vessels and tubes, in which the sap and other fluids circulate. The sap is in the first place taken into the roots, probably by means of the long fibrous filaments which are usually extended in every direction, and conveyed into what are called the *central vessels*. These are so called from their being arranged, in annual shoots and herbaceous plants, around the pith or centre of the stem. They are constructed of fibres which are wound spirally around them and are thence sometimes called the spiral vessels. This arrangement probably contributes to the motion of the fluids they contain. By these vessels the sap is carried up the stem and distributed to the different branches, and thence to the leaves, flowers, or fruit. In the leaves it circulates and is there exposed to the influence of light, heat, and air; and is no doubt perfected and elaborated by the processes which it undergoes. Returning from the leaves, it descends in a different set of vessels situated in the bark, and in its descent contributes to the growth and nourishment of the plant by depositing new layers of vegetable matter between the bark and the stem.

This is the course of the circulation in annual plants, where there is an entirely new growth every year from the root. But in trees and shrubs where the same trunk or stem continues from year to year, the arrangement, though essentially the same, is a little varied. The central vessels are not situated directly around the pith, but in the external layer of wood called the *alburnum*, which is always the growth of the preceding year, and performs this office only for one season, being afterwards surrounded and enclosed by a new layer of the same kind. Hence the trunks of trees are formed by layers of wood, which have been yearly deposited around the centre, and have successively afforded a passage for the sap, by means of the central or spiral vessels, to ascend into the branches and leaves. From the leaves the sap descends through the vessels of the internal layer of the bark, as in the former case, and in its descent gradually contributes to the formation of the alburnum for the next year. That part of the bark, also, which has thus once served the purposes of circulation, like the alburnum, is afterwards thrown aside, and its place is supplied by a new layer formed on its inside between it and the alburnum. Hence the large quantity of thick and dead bark which is often accumulated upon the outside of the trunk and branches of old trees.

This is a slight sketch of some of the most important points in the vegetable circulation. It appears from this, that the principal seat of the growth and nutrition of plants is in the bark and alburnum, and that all the new matter yearly added, is deposited on the outside of the latter and the inside of the former—that the growth of one year is only subservient to the circulation of the next, and is ever afterwards of use merely in giving strength and stability to the trunk in order to support the increasing size and weight of the branches, leaves, &c. The wisdom and beauty of this provision, by which that portion of the plant, which has become useless for every other purpose, is thus made to answer a very important end, are sufficiently obvious; and it is rendered necessary by the circumstance that plants do not like animals arrive at a definite size and there cease, but go on growing to an indefinite extent, and consequently require corresponding increase of strength in those parts which are to support them.

But besides this circulation, which is the most important and interesting part of the vegetable economy, and is also the best understood, the fluids of plants are no doubt subjected in different parts to a variety of operations, and undergo many changes. There are many other vessels besides those already mentioned, whose office is not perfectly known, but which contribute probably in some way to the elaboration of the different principles found in plants, such as gum, resin, sugar, &c. or are subservient to the performance of their functions. The difficulty of accurately examining the minute structure and organization of vegetables is very great, and it is probable that we shall always remain ignorant of many highly important parts of their physiology.

It appears from this account, that those parts of plants, which perform the functions necessary to their nutrition and growth, are strictly annual. So that all plants are either annual, that is, wholly renewed every year, or at least have the circulating vessels, and all the organs taking an active part in their economy, annually renewed, viz. the alburnum, the bark, the leaves, the flower, &c. This circumstance affords another very obvious general distinction between the vegetable and animal kingdoms; in the latter, nothing of the kind is to be observed; there is in no case such a renewal of any of the organs of which an animal is composed,—any at least of those concerned in performing important functions. It is true that some of the subordinate parts, such as the hair, the cuticle or scarf skin, the nails, teeth, feathers, &c. are occasionally and sometimes annually renewed in certain kinds of animals. But there is no change in any of the principal organs; the circulating system, the lungs, the stomach, &c. always remain the same.*

The plan of this work does not admit a more full account of the structure, functions, and classification of the vegetable world; and we proceed therefore to an examination of the animal kingdom.

CHAPTER III.

OF THE STRUCTURE OF ANIMALS.

SECTION I.

General Classification of Animals.

In order to treat clearly of the animal kingdom, it is necessary to consider it according to some method of arrangement, by which those animals that most resemble one another are connected together for the convenience of description. This arrangement is founded upon their form and structure, and separates them into various divisions and subdivisions accord-

* It may here be observed, that in vegetables there is none of that absorption of the different parts which takes place in animals. The matter of which they are composed, being once deposited, is never taken up again; whilst in animals there is a constant process going on, by which the old matter is taken away and new deposited, and the organs thus renewed. Perhaps this end is intended to be answered in vegetables by the annual reviving of their circulating system.

ing to their degree of similarity, and the points in which their structures correspond. Such a system of arrangement is called a Classification of the Animal Kingdom; and, as an accurate acquaintance with the principles on which it is founded, is of great assistance to the student of natural history, I shall proceed to present a general view of that which is most commonly received at the present day.*

In surveying the long series of animals, from the lowest and most insignificant worm, up to man, the lord of the creation, and examining the structure of their bodies, and the mode in which they are enabled to carry on the functions of life, we observe certain lines of distinction among them, which afford ground for arranging them, in the first place, in two grand divisions. Those of the first grand division are possessed of an internal skeleton, a system of bones covered by the flesh, which serves to give form, support, and strength to their whole fabric, and to assist in containing the various internal organs, whose actions serve to keep up the life and vigor of the system. Those of the second, are not possessed of any such skeleton, but consist of a collection of organs more or less distinct, without any solid basis, and are generally of a soft yielding texture, though occasionally covered and protected externally by a shell or other hard covering. We observe farther, that, in animals of the first kind, the blood is always red; in those of the second kind, it is, with a few exceptions, white.

In those of the first kind, there is always a bony case called the *cranium* or skull, which contains the brain; and a number of bones called vertebræ, connected together, so as to form a long column, usually called the spine, the back-bone, or the vertebral column. This column contains a canal extending its whole length, which receives the spinal nerve or marrow, as it passes out of the skull, and conveys it along the trunk, to be from thence distributed to the various parts of the body. It is as it were the main pillar or common support of all the rest of the skeleton; and hence the animals possessed of it are called VERTEBRAL animals, as this forms the most striking characteristic which is common to them all.

* This system is principally derived from Cuvier. Its general outlines are, I believe, almost universally admitted as the most accurate and philosophical of any yet proposed. In its details, it has not yet perhaps been so generally received; but I have nevertheless ventured to follow it principally in this work, since there can be little question of its superiority, or that it will ultimately supersede those of all other naturalists.

In animals of the second kind, there is no skeleton, and of course no vertebral column. The brain and nervous system are not therefore protected by any bony covering. These organs do not resemble the corresponding ones of the vertebral animals, but are less distinct and apparently less important. They have not many common points of resemblance, but as they none of them possess a back-bone or a skeleton, they are denominated from this circumstance INVERTEBRAL animals, i. e. without vertebræ.

The two first grand divisions of the animal kingdom, then, are 1. VERTEBRAL, such as man, quadrupeds, birds, fishes, &c. having a skeleton and red blood; and, 2. INVERTEBRAL, such as worms, insects, shell-fish, &c. having no skeleton and white blood.

But in examining the first division, we find farther differences. Man, quadrupeds, whales, and birds, have all a temperature above that of the air or water in which they reside. Their flesh is warm, and as this warmth is supposed to depend upon the temperature of the blood, we call them *warm-blooded.* On the other hand, frogs, toads, lizards, serpents, and fishes, have all a temperature varying but little from that of the air or water in which they live. They impart to us, when we touch them, the sensation of cold. Hence we call them *cold-blooded.* Here then is afforded ground for a subdivision of the vertebral animals into the warm-blooded and the cold-blooded.

Again, the warm-blooded animals are capable of being divided into two classes. A part of them produce their young alive, nourish them during infancy by their own milk, from organs called their mammæ or breasts, and are hence called *mammalia* or *mammiferous* animals. This class includes man, quadrupeds, whales, porpoises, &c. Another part produce their young by means of eggs, which they hatch by the heat of their bodies, and support by food which they provide for them as soon as they come out of the egg. This class includes birds.

The cold-blooded vertebral animals also form two classes. The first contains those which breathe only pure air, and cannot exist without it, as tortoises, frogs, serpents, &c. These are called reptiles. The second contains those which breathe by gills or branchiæ, through the medium of the water. This class includes all the true fishes; for the cetaceous animals, mentioned above, are not, strictly speaking, to be numbered among fishes.

The invertebral animals are not capable of so satisfactory and accurate an arrangement. Their structure is not yet sufficiently understood; but they may be divided into five classes, according to such circumstances of resemblance as the present state of knowledge with regard to them admits. These classes are 1. Insects. 2. Crustacea, as the lobster, crab, and craw-fish. 3. Mollusca, as the oyster, the snail, the cuttle-fish or squid, the clam, and the quahog. 4. Vermes or worms, as the earthworm, the leech. 5. Zoophytes, as the star-fish, the sea-urchin, the sea-anemone, the sun-fish, the polypes, the sponges, and the animalcules. These classes will all be more particularly described hereafter.

The whole animal world then is arranged in two grand divisions, and nine distinct classes, as in the following table.

I. *Vertebral Animals.*

1. Mammalia, } Warm-blooded.
2. Birds, }
3. Reptiles, } Cold-blooded.
4. Fishes, }

II. *Invertebral Animals.*

5. Insects.
6. Crustacea.
7. Mollusca.
8. Vermes or Worms.
9. Zoophytes.

After these greater divisions into classes, there are several smaller divisions, of which it will be useful to give some account.

Classes are subdivided into a greater or less number of orders; and these are distinguished by some important, clear, and remarkable peculiarities of conformation and structure, which are common to all the animals included under each of them. Thus, in the class Mammalia, the order Quadrumana includes those animals which have hands upon all four of their extremities, such as monkeys and apes; the order Ruminantia, those which ruminate or chew the cud; the order Carnivora, those adapted to feed principally on animal food. In the other classes, the divisions are of a similar kind.

Orders are subdivided into genera. These comprehend animals which have a general external resemblance to each other, a kind of family likeness. Thus the genus Felis includes all those of the cat kind; and these animals, although differing one from another very much in size and colour, have yet a very close resemblance in their general form, figure, character, and habits of life. The genus Canis includes those of the dog kind; the wolf, the fox, the jackal, and the domestic dog, of which the same remark may be made. Thus too the horse, the ass, and the zebra, are all of the same genus Equus, on account of their obvious general similarity.

Again, GENERA are made up of SPECIES. Each distinct kind of animal constitutes a species, and they are known from one another by their size, colour, form, and various other circumstances of external appearance. There are then as many species as there are sorts of animals. Thus the cat is one species, the tiger is another, and the lion, leopard, jaguar, and catamount, are also separate species; but taken together with others, they constitute the genus Felis. Thus too the genus Canis contains the dog, the wolf, the jackal, and the fox, which are all so many distinct species. The genus Sciurus contains the grey, red, striped, and several other kinds of squirrels. In treating of any particular animal, naturalists are accustomed to designate it by a name derived from its genus and species. This name is composed of two words; the first being the name of its genus; and the second being either altogether arbitrary, or else expressing some circumstance relating to the colour, size, or residence of the animal, which serves in a degree to distinguish it from others. The first is called its generic, the second its trivial or specific name, and they correspond very closely to the names of human individuals; the generic terms answering to the *sirname* which designates the family to which any one belongs, and the trivial to the *christian* name which designates the particular individual.

To give an example; the different species of the genus Felis, above mentioned, are distinguished one from another in the following manner. The lion is called Felis leo; the tiger, Felis tigris; the leopard, Felis leopardus; the jaguar, Felis onca; the lynx, Felis lynx; the serval, Felis serval, &c. In the genus Canis, the dog is called Canis domesticus; the wolf, Canis lupus; the black wolf, Canis lycaon; the fox, Canis vulpes, &c. In this way, each animal is capable of being clearly and accurately designated, by a name which is not so liable to mistake and confusion as its common one, which is sometimes applied to several different species. This is called the scientific or sytematic name.

Each kind of animal, then, constitutes a distinct SPECIES; a number of species taken together form a GENUS; those genera which have important and well defined points of resemblance in structure and conformation, common to all, are placed together in an ORDER; whilst upon a similar principle, but more extensive in its application, these orders are marshalled into separate CLASSES.

SECTION II.

Class I. Mammalia.

The Mammalia are placed at the head of the animal kingdom. It is to this class that man, considered as an object of natural history, properly belongs; and beside him, the animals of this class are distinguished for a more perfect bodily structure, for more varied faculties, more delicate sensations, a more elevated intelligence, and greater capability of improvement by imitation and education, than those of any other. Man is arranged with them, because he nearly resembles them in structure and organs, though raised in reality far above them by the possession of intellectual and moral powers almost infinitely superior.

There is a very considerable similarity in the anatomical conformation of all the animals of this class. The greater part of them are intended for motions confined to the surface of the earth; but a few are capable of mounting into the air, as the bats; and others are adapted for a life confined to the water, as the whales. But notwithstanding these differences in their mode of life, their principal organs are nearly similar in the general plan of their construction. We shall begin therefore by a description of them as they exist in man, and afterwards point out such important modifications as exist in other animals which differ from him.

The human body is divided into the head, trunk, and extremities.

The head includes the *cranium*, or skull, and the face. The skull is a large bony cavity, composed of several wide and thin bones united together by sutures. It contains the brain, and gives origin to the spinal marrow, which passes out of it at a hole situated in its lower part, and goes to the back-bone. The face is formed of the upper and lower jaws, and of the organs of seeing, smelling, and tasting. The bones which form the basis of these organs, are very numerous and difficult to describe; they are united by sutures, and, when taken together, give the general shape and constitute the features of the countenance.

The head is placed upon the top of the back-bone or vertebral column, and is capable of a number of motions upon it. The back-bone is the main support of the trunk of the body, and is composed of twenty-four distinct vertebræ, placed one above another, so as to form a kind of pillar or column. The body of each vertebra consists of a solid cylindrical piece of bone, and this is united firmly to those contiguous to it, above and below, by strong and elastic cartilage. The body of the vertebra is solid, but behind it and on each side are projections of bone, called processes, which are arched over and connected together in such a manner, as to form a canal from one end of the spine to the other. This canal contains the spinal nerve or marrow, and between each vertebra are holes through which branches are sent out to the different parts of the body.

Seven of the vertebræ belong to the neck, twelve to the back, and five to the loins. They are called respectively the cervical, dorsal, and lumbar vertebræ. They increase in size from above, downwards, so that the lumbar vertebræ are much larger, thicker, and stronger than those of the back and neck. To the dorsal vertebræ are affixed twelve ribs on each side, which arch over forwards, and are joined to the sternum or breast-bone by means of cartilage or gristle. In this way they form the cavity of the thorax or chest, which contains the heart and lungs. This cavity is terminated below by a muscular membrane, called the diaphragm or midriff, which extends from the edges of the lower ribs, and stretches across to the back-bone, so as to form a complete curtain or division between the chest, and the abdomen which lies below it. This is another important cavity, usually called the belly, containing the stomach, liver, spleen, caul, alimentary or intestinal canal, kidneys, &c. It is formed below by four bones attached to the lower end of the back, which spread out and constitute a sort of basin, called the pelvis. This serves as a solid basis to support all the heavy organs contained in the abdomen, which is protected before and at its sides only by skin, fat, and muscles, and has no bones except below and behind.

The limbs of man and other animals are called their extremities. The arm, or upper extremity, is composed of the shoulder, which has two bones, the collar-bone and shoulder-blade, by which it is connected with the trunk; the arm, which has only one bone, long and firm, extending to the elbow; the fore arm, which has two long bones parallel to each other, extending from the elbow to the wrist; the wrist, having eight small and irregular bones; and the hand, on which there are four fingers, each with four bones, and the thumb with three. These bones are united together, so as to form moveable joints of various degrees of flexibility and power, by means of firm substances called ligaments. The surfaces which move upon one another, are covered by a smooth polished substance that renders all their motions easy and free from impediment.

The lower extremities are constructed in a similar manner. The thigh-bone, the largest and strongest bone in the body, is connected above with one of the bones of the pelvis, by means of a large round head, which is received into a socket of corresponding size, and thus forms the hip-joint. Its lower end contributes to form the knee-joint together with the knee-pan and one of the two bones of the leg. These last are parallel to each other, and extend from the knee to the ankle. The ankle is composed, like the wrist, of a number of small bones, of which there are seven, one of them projecting behind to form the heel. The toes have the same number of bones as the fingers and thumbs, but are shorter and less capable of free and extensive motions.

These different bones are covered by muscles, fat, and skin, which constitute the principal soft parts of the body. The muscles are fibrous organs, attached to the bones generally by tendons, whose contractions put the bones in motion and thus originate all the movements of which we are capable. They act in fact like cords attached to levers, and operate according to strict mechanical principles.

The organs by whose operation the digestion of food, the circulation of the blood, and the other important functions are performed, are contained in the three cavities of the cranium, the thorax, and the abdomen, which have been already cursorily described. We proceed to a consideration of these several functions, beginning with that of digestion.

The food is in the first place taken into the mouth, mixed with the saliva, and ground into a kind of paste, by the action of the jaws and teeth. It is then swallowed through a long muscular canal, the œsophagus or gullet, which passes through the thorax behind the heart and lungs near the back-bone, and is conveyed, through its upper or cardiac orifice, into the stomach. This is an irregularly shaped muscular bag or sack, situated in the upper part of the abdomen, at the spot usually called the pit of the stomach. It is capable of great distention or contraction, according to the quantity which is put into it. In the stomach, the food is acted on by a peculiar fluid, called the gastric juice. It has no powerful sensible qualities, and is nearly tasteless and destitute of odour; but its operation upon the substances exposed to its influence, is very decided and powerful. They are gradually reduced, of whatever kind they may be, to one homogeneous mass, of a grayish colour and a consistence like that of thick cream, called *chyme.* This operation being completed, the chyme passes out of the stomach, by its lower or pyloric orifice, situated towards the right side, into the intestines, which form a long canal, and, taken together, are many times longer than the body.

In the intestines, the chyme is subjected to the action of the bile and pancreatic juice. The bile or gall is a brown-coloured, viscid, and very bitter fluid prepared by the liver, a large organ on the right side just beneath the ribs, and collected into the gall-bladder, where a part of it is reserved for use. The pancreatic juice resembles very nearly the saliva in colour and appearance, and is prepared by the pancreas, an organ situated just below the stomach. The effect of the mixture of these two fluids with the chyme, is to separate it into two parts. One of these is a thin, milky fluid, called *chyle*; the remainder consists of those portions of the food which are not fit for the nourishment of the system, but are rejected and thrown out of it as useless. The chyle is gradually absorbed by capillary vessels, called the lacteals, which open into the intestines through nearly their whole course, and convey it into a vessel called the thoracic duct. This duct ascends from the abdomen along the back into the thorax, and there empties its contents into the left subclavian vein, or the vein coming from the left arm, where the chyle is immediately mingled with the mass of blood and enters with it into the circulation. The chyle is the same, from whatever substance it is prepared, when the digestion is perfect. Some kinds of food, however, are capable of furnishing a larger proportion of it than others; this is the case with animal food, of which it takes a smaller quantity to supply the system with nourishment, than of vegetable. Animal substances are also more easy of digestion; and hence, it is observed, in those animals which subsist on vegetables, the digestive organs are more various, extensive, and complicated, than in those which are carnivorous, as the changes to be produced in the nature of the aliment are greater.

The chyle, being mixed with the blood, becomes a part of it, although it is not known where or how its change from the white to the red colour is effected. It is then circulated throughout the body, by the heart, the arteries, and the veins. The heart is a hollow muscular organ, the main spring of the circulation; the arteries are long cylindrical canals or pipes, carrying the blood from the heart to the different parts of the body; the veins are vessels of a similar form and structure, bringing the blood back to the heart after it has gone the round of the circulation.

The heart in man is a double organ, that is, it consists of two complete and distinct organs, united together into one mass, but performing their functions without interference or connexion. These two parts are called the right and left sides of the heart; and each has two distinct cavities, called auricles and ventricles. The right side of the heart receives the blood from the body at large, and sends it to the lungs; the left receives it from the lungs, and sends it to the body. The heart is of a conical shape, and is situated in the thorax, just within the sternum, a little inclining to the left side. It is however placed with the apex, or point of the cone, extending downwards and to the left, so that it touches the ribs at the spot where its beating is usually felt, and hence has usually been supposed to lie entirely on the left side. The main body of the heart is composed of the two ventricles, which are strong muscular cavities, the left far more so than the right; the auricles are situated around the base of the organ, seeming rather to be loose appendages than constituent parts of it.

We shall begin with the course of the blood at the point where it receives its new supply from the chyle. The subclavian vein, after uniting with the vein from the other arm, and the veins coming down from the head and neck, conveys its blood immediately to the right auricle, where it meets with that brought from the lower parts of the body. The two trunks which bring the venous blood in this way to the heart, are called the descending and ascending venæ cavæ. They pour their blood into the right auricle, which contracts and expels it, through an opening for that purpose, into the right ventricle. This opening is guarded by valves, which prevent the flowing back of the blood, by completely closing the passage. When the ventricle has become distended, it contracts in its turn, and the blood, being prevented by the valves from returning to the auricle, is thrown forward into the pulmonary artery, which carries it to the lungs. This passage is also guarded by valves.

At the time of its passage through the right side of the heart, the blood is of a dark bluish red or purple colour, approaching almost to black. It is generally called black blood, and is neither fit for circulation in the vessels, nor for the nourishment of the different parts. In this state it is sent to the lungs. These fill up all that part of the cavity of the chest which is not occupied by the heart, which they surround almost upon all sides. They consist principally of a collection of blood and air vessels, and are constantly supplied with air, drawn in through the windpipe, and distributed to every part of them. The blood is circulated throughout their substance, by the branches of the pulmonary artery, and is, in its course, exposed to the influence of the air. By this means, its colour is changed to a bright crimson or vermilion, and it becomes again fit for the purposes of life.

It is now brought back to the left side of the heart, by the pulmonary veins, and passes through the left auricle and ventricle, in a manner almost precisely similar to that which has been already described with regard to the right side. The left ventricle, from its superior size and strength, gives to the blood a more powerful impulse, than that which it receives from the right, and this is the more necessary, because it has a much wider and more extensive course to traverse. From the left ventricle, it is thrown into the aorta, the great artery which supplies the whole body with blood. This artery ascends from the heart for a short distance, arches over, sends branches to the head and arms, and then descends behind the heart, and distributes them to the other parts of the system.

The branches thus disseminated throughout the body, are subdivided again and again to an almost inconceivable degree of minuteness, and finally terminate in a system of vessels, called *capillary* vessels. These pervade every part, and the blood, after passing through them, enters into another set of vessels, the veins, which, as it proceeds, gradually collect together and enlarge in size, till they terminate, as has been before remarked, in two large trunks at the right auricle of the heart.

In the capillary vessels, it undergoes a change in its qualities, precisely the opposite to that which takes place in the lungs. It becomes, from a bright red colour, of the same dark red which it was described to possess upon passing through the right side of the heart, in its passage to the lungs. The cause of this change is not understood; but it is presumed to proceed from the office which the blood performs in the nutrition of the body during its circulation, and by which some of its elements are abstracted from it, and combined with the texture of the organs.

The brain in man is the grand centre of sensation and perception. It is the instrument through which the mind maintains its connexion with the body; and this connexion is extended from the brain to other parts by means of nerves. The brain is a large organ, of a peculiar texture, occupying the whole of the cavity of the cranium, and consisting of several distinct parts. Several pairs of nerves proceed from it through different apertures in the skull, and are distributed to the parts about the head, to convey to them the powers of sensation and motion. But beside these, there is another large single nerve passing down into the canal formed by the vertebræ, already described, and supplying the greater part of the body and limbs.

Through the nerves, impressions are transmitted from all parts of the body to the brain, and, on the other hand, all the acts of the will produce an effect upon the different organs by their means. The nerves are necessary to the exercise of the senses, (which in man are five; seeing, hearing, smelling, tasting, and feeling;) for, if the nerve going to the organ of either of these senses be injured, the mind no longer receives any impression from them, as happens in the disease of the eye, called *gutta serena*. And if the nerve going to any of the limbs be destroyed or obstructed, both sensation and power of motion in that limb are either destroyed or suspended. This happens when a limb, from long continued pressure upon it, is said to be asleep; as, in sitting a long time in one particular position, the nerve going to one of the legs is pressed upon, and, the connexion with the brain being thus interrupted, the consequence is a loss of feeling and motion, which is sometimes so great as to cause the person affected to fall down on attempting to walk.

The senses, taken all together, are more perfect in man than in any other animal. Yet in each of them, individually, he is probably excelled by some particular species. Thus, in sight he is exceeded by the vulture and the eagle, in hearing by the greater number of rapacious quadrupeds, in smell by the dog, in taste by a great many animals, and in nicety and delicacy of touch and feeling, by most insects.

The skeleton and the internal organs of other animals, of the class Mammalia, exhibit fewer differences from those of man, than their external appearance would lead us to imagine. They are generally of such a nature, as to adapt the animal for the particular kind of life which he is intended to lead, the motions which it is necessary for him to perform, and the food upon which he is to support himself. Thus the limbs of monkeys are calculated for climbing, those of most others for walking on all fours; the fore legs of some animals are adapted for free and extensive motions and furnished with claws, that they may seize and secure living prey, as in the tiger and the lion; those of others are limited and confined in this particular, and terminated by hoofs, as the deer and the horse, being intended to feed upon vegetable substances alone.

It is upon the consideration of differences of this kind, that the division of the animals of this class into orders is founded. The structure of an animal is always found to correspond to its character, mode of life, and food; and those, therefore, which have a similar structure, resemble one another to the same extent in other particulars. From the formation of the anterior extremities of an animal, we may judge of the degree of address of which he is capable, and of the kind of motions he is able to perform; and, from the structure of his teeth, what is the nature of his food. Thus, the fore feet of animals may be either enveloped in hoofs, like those of the horse and the ox; or armed with claws, like those of the lion; or furnished with slender nails, like those of man and the ape; and the perfection of the sense of touch will be in proportion to the delicacy of these organs respectively. Thus too, there are three kinds of teeth, the incisory or cutting teeth; the canine or dog teeth; and the molar or grinding teeth; but all animals have not each of these kinds of teeth, nor are they of the same shape and formation in all animals. The molar teeth, for instance, in the carnivorous animals, are sharp and and cutting, fit only for the chewing of flesh; and in the herbivorous, they are broad, with surfaces adapted for grinding grain or the fibres of vegetables, which require more mastication than flesh, before they are capable of being digested.

It is principally from a regard to these parts, that naturalists have proceeded in the arrangement of the Mammalia. The orders thus formed are nine in number, as follows :—

1. The *Bimana* or *two-handed* animals. Man is the only example of this order. He has hands upon his superior extremities alone. He has nails of a thin and delicate texture, which give to his thumb and fingers a wonderful delicacy of touch.

2. The *Quadrumana* or *four-handed* animals, comprising apes, monkeys, and baboons. They have hands upon all four of their extremities, but less perfect than those of man.

3. The *Carnivora* or *carnivorous* animals. These have no hands, but their feet are furnished with claws. This is a very extensive order, and embraces a great variety of animals.

These three orders have all the three kinds of teeth, which differ however, in shape and strength, according to the habits and food of the different species.

4. The *Rodentia* or *gnawers ;* so called from the structure of their fore teeth, which are particularly adapted for gnawing. They have no canine teeth ; and their claws are similar to those of the *carnivora.* This order contains rats, squirrels, rabbits, &c.

5. The *Edentata* or *toothless* animals; so called because they are deficient always in the incisive teeth, and sometimes have no teeth at all. Their toes are terminated by large and crooked nails, which obstruct both their sensations and motions. The sloth and armadillo are in this order.

6. The *Ruminantia* or *ruminating* animals, are those which chew the cud. They are cloven-footed, and have moreover no incisive teeth in the upper jaw. Among these are the ox, camel, lama, stag, and antelope.

7. The *Pachydermata* or *thick-skinned* animals. This order includes a considerable variety of other animals with hoofs, but which do not ruminate ; as the horse, the wild boar, the hog, the tapir, and the elephant.

8. The *Cetacea*, or animals of the *whale* kind, distinguished by having no posterior extremities, and their anterior so constructed as to answer the purpose of fins. In this order are whales, porpoises, and dolphins.

9. To these may be added the *Marsupial* animals, which do not come strictly under either of these orders, and are distinguished from all others, by the possession, in the female, of a *bag* or *pouch* (marsupium) on the outside of the abdomen, for

the purpose of holding their young after birth. Such are the kanguroo and opossum.

We proceed to give some further account of these different orders of the Mammalia.

I. *Bimana.* Some writers have affected to believe that man was originally intended to be a quadruped; and that he has learned only from long experience the mode of walking erect and of applying his hands to the purposes for which he now employs them. They have represented him as only a more perfect kind of ape; and have been fond of collecting stories of wild men who have been found living like beasts in the midst of forests, destitute of speech and the arts of life; and of races of apes and monkeys who can walk erect, and imitate the manners, gestures, and mode of life of men; thus endeavouring to prove a near connexion and relationship between man and these animals.

It is undoubtedly the case, that man, in his external form, resembles this order of animals much more nearly than any other; but he is yet by no means more nearly allied to them in this respect, than they are to some others, which are yet always considered of a distinct kind. The fact is, that since the animal kingdom forms a series of individuals rising, by a regular gradation, from a very humble and imperfect structure, up to a very perfect one, there will necessarily be certain points of resemblance between those which stand nearest to each other in this series. Hence the tribe of apes, which stand nearest to man, resemble him more than any other animal does, but not so much as many other animals resemble them. There is a greater difference between man and those species which are next below him, than there is between any other two species, which rank next to each other, in the whole animal kingdom. So that there is, in truth, no more reason for saying that man is only an improved and educated ape, than there is for saying that a bee is only an improved and educated fly, a cow an improved sheep, or a horse a perfected ass.

Man is distinguished from all other animals of the class Mammalia, by his erect attitude, and his power of walking upon two legs. This is naturally the case with no other animal. Some are capable of being taught to walk upon their hind legs; but they never do it with ease or from choice. The ape and monkey have, it is true, hands very like those of the human species, which they are capable of using with great address and effect; but then they have not feet or legs which enable them to walk upright; their feet are, in fact, formed like hands, having a palm, and a distinct thumb, opposed to the four fingers, and are thus able to grasp objects. The foot of man is very different. It has nothing which does the office of a thumb, and the sole does not perform that of a palm. It is flat, inflexible, and fit only for the purpose of walking. Apes, on the contrary, are adapted for climbing; and hence the peculiarity of their structure, which enables them to grasp the small branches of trees with their feet as well as their hands. Strictly speaking, then, these tribes are principally distinguished from man by having four hands instead of two; and hence man is called a *two-handed* or *bimanous* animal; and apes, monkeys, and baboons, *four-handed* or *quadrumanous* animals. This alone would be a sufficient distinction; but there are many others founded upon a variety of considerations, derived from the general structure of man. His head is larger and his face smaller in proportion to his size, than that of the monkey. His eyes, his ears, in short, all his senses are adapted to the erect position. He is incapable of going upon all fours with any facility, his lower extremities being so long, as to render the posture of his head painful and even dangerous.

The structure of man, and his faculties of mind, give him great advantages over other animals in point of adroitness, skill, and address. His erect position gives him the free use of his hands, which, though they have a general similarity to those of the monkey, are yet far more delicately and perfectly constructed. The thumb is larger; the fingers, all except the ring-finger, have distinct motions; the nails present excellent points of support, so as to admit of the handling of very small bodies; and the arms have unincumbered and various motions in every direction. Still he is inferior, in point of strength, to most animals of his size; he is slow in running, is without natural means of defence, and has no natural covering. So that man, who, in the social state, is the lord of this lower world, the conqueror of the rest of creation, is, by nature and when alone, the weakest, the most helpless, and the most defenceless of all animals.

There are several distinct races of mankind inhabiting different portions of the earth, which differ one from another more or less in form, in features, in complexion, and in character. The cause of these varieties has never been satisfactorily pointed out. They have been attributed to climate, to situation, to manner of life, &c. but none of these circumstances appear sufficient to produce them, and we therefore still remain in ignorance on the subject. These distinct races may be considered as five in number. 1. The Caucasian. 2. The Mongolian or Tartar. 3. The American. 4. The Negro or African. 5. The Malay.

1. The Caucasian. The individuals of this variety are distinguished by the beautiful oval form of their heads; a large and full forehead; regular and distinct features of the face, which is small and narrow in proportion to the cranium; a white skin, varying from a light rosy tint to a deep brown; and hair and eyes of various colours. This race is called Caucasian, because its origin is referred by tradition to the group of mountains lying between the Black and Caspian seas, among which Caucasus has been celebrated. From thence if has spread itself over a considerable part of the known world. The inhabitants of of Caucasus itself, the Georgians and Circassians, are to this day considered as the most beautiful specimens of the human form. In the ancient world, the most celebrated nations belonged to this race. The Assyrians, the Chaldeans, the Phenicians, the Jews, probably the Egyptians, the Persians, the Scythians, the Parthians, the Greeks, the Romans, &c. were all of Caucasian origin. In modern times, nearly all the nations that inhabit the western part of Asia, nearly all the nations of Europe, and the descendants of Europeans in America and other parts of the world, are of the same race.

They have been always distinguished for superior intellectual and moral qualities. With a few exceptions, they have always maintained a decided ascendency in arms over the people of the other races, and have acquired a superiority over them in all the elegancies, refinements, and luxuries of life. They have been for ages the depositaries of literature, philosophy, science, and the arts; and have carried the human character to the highest degree of excellence it has ever reached. All that is beautiful and enchanting in poetry and the fine arts, all that is sublime and awful in religion, have belonged to them.

2. The Mongolian race is principally found in the eastern parts of Asia. It is distinguished by a low stature, by projecting cheek bones; a depressed and retreating forehead; features not strongly marked; eyes narrow and oblique; a nose

somewhat broad and flat; thick lips; black, strait hair; thin beard; and an olive complexion. In this division are to be arranged the inhabitants of the great empires of China and Japan; the hordes of Calmucks, of Mongols, &c.; the ancient Huns; the Finnish tribes of northern Europe, as the Laplanders; the Kamtschadales; the Esquimaux indians inhabiting the northern parts of America; and a great number of other nations and tribes of less note.

The individuals of this race are inferior in moral and intellectual qualities to those of the preceding. They have made but slight progress in civilization or literature, and have generally remained in a semi-barbarous state. Occasionally they have manifested great vigour and energy in military exploits; and three times have carried the terror of their arms over the greater part of Asia, and even into Europe, under Attila, Zenghis Khan, and Tamerlane. Their conquests have generally, however, been of short duration, as they have not the qualities suited to retain and govern the empires they gain.

3. The African, or Negro, is remarkable for his narrow and depressed forehead; his flat and broad nose; his thick lips; his projecting jaws; black, crisped, and curled hair or wool; black skin and eyes; and some other differences in bodily shape, which it is not necessary to enumerate. These characteristics are confined to Africans, and their descendants in different parts of the world. The individuals belonging to this race have seldom been distinguished for their mental faculties or moral endowments. They have always remained in a barbarous state, and are with difficulty induced to adopt the customs and habits of civilized life.

4. The American race resembles, in many respects, the Mongolian; but differs from it in having more distinct and strongly marked features, and a skin of a copper tint. All the native inhabitants of the new world, with the exception of the Esquimaux, come into this division. In general, they have made small advances in civilization and the arts, and prefer the wandering life of hunters to the comforts of settled habitations. In the empires of Mexico and Peru, was exhibited the highest pitch of refinement, to which they have ever arrived.

5. In the division called the Malay, are included nations differing one from another very much, in form, features, and character, and too imperfectly known to admit of being clearly described. Some of them, as the inhabitants of New Holland,

Van Diemen's Land, &c. resemble very nearly the African race; whilst others, as the inhabitants of Malacca, Sumatra, &c. and also those of the islands in the Pacific ocean, approach sometimes the Caucasian and sometimes the Mongolian.

But, notwithstanding all these differences in man, he maintains every where a decided rank, far above that of any other animal. He is the only one which has the power of communicating its thoughts and feelings by articulate speech; the only one which can properly be said to avail itself of the advantages of society; and the only one that, strictly speaking, educates its young. It is in consequence of these advantages, particularly that derived from association, that he has been enabled, under all circumstances, to acquire and preserve a dominion over other animals, either by subjecting them to his use, or at least making himself the object of their fear. It is in consequence of these advantages, also, that he has been enabled to protect himself against the severity of climates, and thus spread his species over every part of the earth. Naturally tender and defenceless, he could only exist in the most equable and temperate climates; but, aided by the inventions and discoveries of social life, he is enabled to brave the cold of the polar circle, as well as the overpowering heat of the regions on the equator.

Man is only partially governed by instinct. All his knowledge is the result of education and experience. He knows nothing but what he has discovered himself, or what has been taught him by others. By means of language and writing, the discoveries and improvements of one generation are transmitted to the next, and thus are the ground of an almost indefinite progress towards perfection. All other animals, being principally governed by instinct, are stationary; they neither advance nor recede in their manners or habits; by being associated one with another, they do not improve; and, although capable of being educated by man, they do not educate one another. The first swarm of bees that existed, probably constructed as perfect a honey-comb as is done now; they do not improve upon the plan which instinct has pointed out to them; it is a plan which they did not in the first place contrive, and cannot amend. But, if we compare the rude and ill constructed habitations of savage nations with the splendid and luxurious edifices of civilized life, we instantly perceive the influence which language, society, and education have had upon the human race. We are sensible of the great difference between that skill, which is the result of instinct, and that which is acquired by a being capable of reasoning and speaking.

Being thus susceptible of constant progress in improvement, man is found, under different circumstances, in different stages of this progress. In his primitive state, he supports himself upon the flesh of animals, which he destroys in the chase, or upon the wild fruits of the forest. He has not therefore time to devote to the cultivation of the arts, or to the education of his children; he learns nothing but how to construct his hut and his canoe; he clothes himself with the skins of wild beasts; and he observes the natural objects around him so far only as he can make them subservient to his purposes. When he comes into the possession of the domestic animals, the cow, the horse, the sheep, &c. he finds that he can derive an easier and less precarious subsistence from their milk and flesh, than from the products of the chase. He rears, therefore, numerous herds of these animals, and being only occupied in finding them pasturage and shelter, is comparatively at leisure to apply himself to some of the arts of civilized life. He manufactures clothing from their skins and wool, of various degrees of delicacy and elegance. He builds himself more commodious habitations; and from the different degrees of industry and skill, with which different individuals apply themselves to these occupations, arises an inequality of conditions. Some become rich, and others comparatively poor. The rich acquire a disposition to indulge in the comforts and luxuries of life, and this is found to be inconsistent with the wandering and unsettled life which they lead as mere shepherds. Hence they are induced to fix themselves permanently upon particular tracts of country, which come to be considered as their property; and thus they gradually devote themselves to the cultivation of the soil. This enables a given portion of land to support a much greater number of people, than when it was devoted to the feeding of herds; and hence, as agriculture becomes established, the population of a country regularly increases. Society also becomes settled and permanent. Every individual is able to produce more by his own labour, than is sufficient for his own support, and some therefore devote themselves to other occupations, the results of which they exchange with the labourer for his surplus. Nations also exchange with one another their superfluities. Thus commerce is established;

and the arts and elegancies of life are one by one brought to light, as the growing wealth of individuals and nations creates a demand for them.

II. The *Quadrumana*, as has been before observed, approach more nearly to man, both in their internal structure and external form, than any other animal. They differ however in the size and shape of the head, which is proportionably smaller, narrower, and less elevated; in the conformation of the face which has a flat, depressed nose, and very prominent jaws and teeth; in the length of the fore-arm; and in the construction of the lower extremities, which are not calculated for the erect posture, and are furnished with hands, instead of feet like those of men. Their structure fits them evidently for climbing, and their usual places of habitation are trees, on the fruits of which they feed. They maintain the erect position with difficulty; it is a constrained one, since it obliges them to straiten the joints of the hip more than is easy or natural, and to rest their weight upon the outer edges of their feet or hind hands. Generally, then, they employ all four of their limbs in walking or running, but their motions, when upon the ground, are very various and irregular.

They form a numerous tribe, and comprehend a great variety of species, known under the names of apes, monkeys, baboons, &c. These names are generally employed with little discrimination, but they are intended to point out some general differences of form. Thus the apes are destitute of a tail; the monkeys have one of about the length of their bodies; and the baboons a very short one. Beside these, which are confined to the old continent, are the sapajous, which include those belonging to the new world. These have all long tails, which are in many instances of so much strength, as to answer in some measure the purpose of a fifth limb, enabling the animal to grasp with it the branches of trees or other objects, to assist in climbing. These are called prehensile tails.

The orang-outang and chimpanzè are the most celebrated of this order, for their similarity in face and form to the human race; whilst many other species, by their elongated snout, depressed forehead, and other particulars, approach more nearly to other quadrupeds.

The Orang-outang, or wild man of the woods, which is the meaning of the name in the Malay language, is found only in some eastern climates, and has seldom been seen in Europe; although many other animals have been exhibited under that name. He is a native of Malacca and Cochin China, but is principally found in the great island of Borneo in the East Indies. He is from three to four feet in height; his body covered with a thick, red hair; his forehead high and full; and his face of a bluish colour. He is mild and docile, is easily tamed, and becomes attached to those about him. He is able, in consequence of his bodily form and organs, to imitate very accurately a great variety of human actions; but is, on the whole, not more remarkable for sagacity and intelligence than the dog.

The Chimpanzè is a larger animal, and has been said by travellers to equal or exceed the size of man. This, however, is not well authenticated. His body is covered with black or brown hairs. He can be taught to walk, to sit, and to eat like men. He is a native of Congo and Guinea, lives with his fellows in troops, and, by means of clubs and stones, repels the attacks of man and other animals. It has been said, that he constructs for himself a hut with the foliage and branches of trees; but he probably does little more than provide, in this way, a very rude shelter for himself against rain and storms.

The Pongo is probably the largest of the animals of this order, and is a formidable and ferocious creature. He inhabits the island of Borneo, and is, from the structure of his posterior limbs, as well able to support himself in the erect posture, as either the orang-outang or chimpanzè. His history has been confounded with that of those animals, and his character and many of his habits have been attributed to them. But he is in fact very different in some important particulars; as the shape of his head approaches that of quadrupeds, and his muzzle or snout is very long and projecting.

One of the most remarkable species among the baboons, is the great gray baboon (Simia hamadryas) inhabiting Arabia and some parts of Africa. He is more than five feet in height, and is very ferocious. His head and shoulders are covered with a long growth of gray hair, which has the appearance a large full-bottomed periwig, and, combined with the gravity of his countenance, gives him a singular and grotesque appearance. He is called by the French naturalists, Papion à perruque.

A few of the American monkeys, or Sapajous, are furnished with a pouch or bladder connected with the wind-pipe, which gives to the their voice an enormous volume and a tremendous tone. They are called from this circumstance *Howler* monkeys.

Some of the smaller and more inoffensive species of the Quadrumana are playful, peaceable, and amusing little animals; but in general they are a noisy, chattering, mischievous race, whose distorted resemblance to the human face and figure only renders them more hideous and disgusting.

III. *Carnivora.* This order includes a great number and a great variety of animals. They are furnished with the three kinds of teeth, but these differ more or less in shape from those of man and the monkeys, so as to be adapted for the mastication of animal food, upon which they subsist, either in part or altogether. They are subdivided into several tribes or families, accordingly as they are more or less carnivorous. In some of these tribes, the molares are very sharp and cutting, and thus indicate that the animal feeds entirely upon flesh; in others, they are broader, being adapted partly for the mastication of vegetable food; and, in others, they are armed with a number of points or cones, which are fitted for a diet consisting principally of insects. Their fore legs are capable of pretty free and extensive motions, and are furnished with nails or claws, but no thumb; whence they are far inferior in point of address to the apes. They are remarkable for possessing the sense of smell to a high degree of perfection. Their organs of digestion are in general less complicated and extensive than those of other animals. The stomach is smaller, and the intestines shorter, animal food requiring less change than vegetable in order to convert it into chyle.

1. The first tribe or family, is that of the Bats. These have some points of affinity with the Quadrumana, and were arranged by Linnæus with man and the monkeys. They are sufficiently distinguished, however, by their wings. These are formed of a thin fold of skin, which extends between the two limbs of the same side, and is likewise stretched across the claws of the fore feet, which are very long and slender, and serve to keep the membrane extended like the sticks of an umbrella. By means of this apparatus, many of them are enabled to fly with a force and rapidity equal to that of birds; but, in others, it answers only the purpose of a parachute to break their fall from lofty places, or to enable them to perform great leaps in their passage from tree to tree. They are principally nocturnal animals, seeking their prey (which consists of insects, small quadrupeds or birds, and flesh of

any kind) in the twilight, and retiring during the day to dark and hidden recesses, where they remain suspended by their claws, till the return of night.

Their eyes are extremely small and apparently of little use; but the cavities of their ears are extensive. They possess the singular faculty of directing their flight with great accuracy and precision, without the assistance of the sense of sight, and even after their eyes have been destroyed. It has been found that, after the complete removal of the eyeball, bats are able to fly about in a room without touching the walls, apparently with as much ease and security as before. What is still more remarkable when several willow rods are placed six inches distant from each other, so as to form a sort of grating, the bats, after the destruction of their eyes, are able to pass backward and forward through the spaces without ever coming in contact with the rods. It is difficult to give any satisfactory account of this phenomenon, and yet the experiments, from which the knowledge of it has been derived, are very well authenticated and have been frequently repeated. It has been attributed to the great extent and uncommon delicacy of the membrane constituting the wings, and of that lining the ear, which have been supposed to render the animal capable of judging, from the impressions made upon it by the air, of the relative distances and positions of external objects.

Bats retire upon the approach of cold weather in the autumn, and pass the winter in a dormant state. They frequently suspend themselves together in large clusters, that by their warmth they may reciprocally assist each other in resisting the effects of the cold. During this period, the powers of life seem to be almost extinct, the temperature of the animal is much lowered, and he becomes lean and exhausted; so that he awakens in the spring in a state of great weakness and emaciation, although in the autumn he may have been very fat.

Beside the common bat, with the appearance of which all are familiar, there are many others, differing a good deal in size and disposition, which inhabit other countries. Among them is the Vampyre bat, which is from five inches to a foot in length, and has membranous wings extending from four to six feet. It inhabits Africa and Asia, but is found most abundantly in the East Indian islands. It is very gregarious, and is found in immense flocks. Five hundred have been counted hanging on a single tree. It does not confine itself to animal food, but subsists also upon fruits and vegetables, and is the cause of great injury to the produce of the countries it inhabits. It has been supposed to suck the blood of persons lying asleep, by making an orifice in some exposed vein, which it does so easily as not to awaken the sleeper, to the soundness of whose slumbers it contributes by fanning him gently with its wings. Hence this animal has received the name Vampyre, and it is thought to have given origin to the ancient fable of the Harpies. It is said to be excellent food.

The Spectre bat is a species very similar in its habits to the one just described. It is a smaller animal, not exceeding seven inches in the length of its body, and two feet in the extent of the membrane of its wings. It is an inhabitant of South America and New Holland, and exists in immense numbers. It has the same propensity for drawing blood as the Vampyre, and is said to cause great injury and destruction among cattle by this means. In New Holland, twenty thousand have been computed to be seen within the compass of a mile. It is of a mild disposition, and is easily tamed and domesticated.

2. The second tribe of this order includes a number of small animals, which feed principally upon insects, and are called *insectivorous.* Many of them pass the winter in a state of lethargy, and during summer they lead a secluded, nocturnal, or subterranean life. Their limbs are short, and their motions very feeble. Among the most worthy of notice are the hedge-hog, the tenrec, the shrew-mouse, and the mole.

The Hedge-hog is remarkable for being covered with short, strong spines instead of hairs, and for the faculty of drawing its head and feet in such a manner under its belly, as to give itself the appearance of a ball covered with sharp bristles. In this way it resists the attacks made upon it, using no other method of defence; and no violence will induce it to alter its form or position. It is a harmless and inoffensive animal, and suffers injuries of all kinds with great patience and forbearance. It is about nine or ten inches in length, inhabits holes and decayed trees, into which it retreats in order to pass the winter. Its skin was used by the ancients for a clothes-brush, and has been sometimes employed for the purpose of dressing hemp.

The Moles are peculiarly adapted, by the structure of their nose and feet, for burrowing in the earth. This operation they perform with great facility and rapidity. So expert are they, that, if put upon the grass where the earth is soft, they force their way into it almost immediately; and even upon a hard gravelly road, they can cover themselves in the course of a few minutes. They feed principally upon the earth-worm, and prefer the soil in which it is to be found in greatest abundance for their residence. They construct habitations of a peculiar form, to be hereafter described, in which they rear their young, and lead a social and domestic life. They sometimes increase in number to such an extent, as to be a serious annoyance to the husbandman.

3. The third tribe of this order possess the characteristics of carnivorous animals in the highest degree. They are endowed not only with an appetite for animal food and a structure adapted for its mastication and digestion, but with strength and courage for seizing and retaining it. They are not all, however, purely carnivorous nor equally ferocious. Some are slow and indolent in their motions and clumsy in their forms, passing the winter in cold climates in a state of lethargy, and being capable of subsisting in a great measure upon vegetable food. Such are the bear, glutton, and badger. There are others, as the weasle, the ermine, the ferret, the polecat, &c. mean in size and appearance, and of a long and lean body with very short legs, enabling them to creep through very narrow apertures. They are small and feeble, but still extremely cruel. Others again, as the dog, the wolf, the fox, and the jackal, are possessed of a good deal of strength, but do not exhibit a proportionate degree of courage and ferocity. But the lion, tiger, panther, &c. are at once the most powerful, the most bloody, and the most ferocious of the animal kingdom. Their fore paws are endowed with prodigious muscular power, and are armed with sharp and piercing nails, which in a state of rest are drawn in and concealed from sight. They are the terror of the forest, feed only upon flesh and blood, and sometimes, when driven by hunger, attack even man himself.

The dog, so well known to all mankind, presents a great variety of shape, size, and colour, according to the different breeds produced by the different situations in which he has been placed. No animal is so completely under the control of mankind. Every individual of the species gives himself up wholly to his master, obeys his voice, acquires his habits, defends his property, and, even in spite of caprice and ill usage, remains faithful till death. This connexion, this attachment, does not proceed so much from necessity, as from a true sentiment of friendship. The dog is the only animal which has accompanied man to every part of the earth, and forms his most useful ally, particularly in the early stages of society, in bringing into subjection the inhabitants of the forest. It has been supposed by some, that the dog was orginally the same with the wolf, and by others, that he is the jackal in a domestic state. But the origin of his connexion with man, is too remote and obscure to allow this question to be determined.

The animals of the cat kind are all of a fierce and bloody disposition, and some remarkable for the majesty and elegance of their form, or the beauty of their skin. The lion and the tiger are the two most celebrated species.

The Lion is a native of Asia and Africa, particularly of the latter; and is found sometimes of the length of eight or nine feet, exclusively of the tail. His appearance is majestic and dignified; and, although entirely carnivorous, he is not remarkable for cruelty or the unnecessary destruction of life, but has been often noted for striking traits of generosity and magnanimity. His muscular strength is immense; a single stroke of his paw is sufficient to destroy some of the larger animals on which he preys; a sweep of his tail will knock down a man; and he is able to carry off an ox, or even a buffalo, when lightened of its entrails, with apparent ease. In populous countries where he is accustomed to the sight, and acquainted with the power of man, he is comparatively timid, and will sometimes even fly before women or children; but in those where he is undisturbed in his dominion of the forest, he defies man as well as all other animals, and has been known singly to attack a whole caravan. The lion, when taken young, is capable of being tamed; and, in a state of confinement, has lived to the age of seventy years.

The Royal Tiger is an inhabitant of the warmer parts of Asia and the Indian islands. He attains to nearly the size of the lion, and is of equal strength, but far more bloody and cruel. He is the scourge of the countries which he infests, and has sometimes almost depopulated whole villages. Such is his vigor and the rapidity of all his motions, that he has been known, when lurking around an army on the march, to spring from a thicket upon a soldier, tear him from his horse and convey him into the forest without being molested. When he has seized a large animal, if uninterrupted, he plunges his head into the midst of the carcass, and sucks the blood. He is not so easily or completely tamed as the lion; but, if taken young, is susceptible of a certain degree of domestication.

4. A fourth tribe of the Carnivora comprehends the amphibious animals, as the Seal and the Morse. They differ from other quadrupeds very widely in their external appearance, whilst their internal structure is very nearly the same. Their limbs are composed of a similar number of bones, arranged in the same way, but so short and so enveloped by their skin, as to be of but little use for walking. But as the intervals between the toes are filled up with skin, they form excellent oars; so that these animals move with great rapidity and address in the water, although they can only crawl awkwardly upon land. They feed principally upon fish; and the structure of their teeth is manifestly that of carnivorous animals. They live almost entirely in the sea, and come upon shore only for the purpose of reposing in the sun and suckling their young. They breathe, however, like other Mammalia; and hence cannot constantly remain under water, but are obliged to return occasionally to the surface for air. Still they are able to live a long time without breathing, and it has been asserted that there is some peculiar conformation about their heart, which renders this possible. But no such peculiarity is found to exist.

The Seals are mild and inoffensive, except when provoked. They are easily tamed, and become attached to those who feed them. Their head resembles a good deal that of the dog. They live together in large herds or families, and are valuable as objects of trade on account of their skins and oil.

IV. *Rodentia*, the Gnawers, are distinguished by the possession of two large incisive teeth in the centre of each jaw, and by the absence of the canine teeth. There is a wide space between the incisors and the molares, which last are broad and evidently calculated for the mastication of vegetable food. This arrangement of their teeth remarkably qualifies them for gnawing, and enables them to penetrate very solid substances; and frequently they feed upon woody fibres and the bark of roots and trees. There is an additional circumstance in the structure of their incisive teeth, which wonderfully adapts them to the use for which they are intended. They are furnished with enamel only upon their front surface, so that the back part, being merely bone, is by gnawing worn away faster than that in front, and of course the front edge is kept sharp and fit for cutting. To remedy the great loss of substance which necessarily takes place, there is a provision by which a constant growth takes place from the root; so that, if one of these teeth is lost by accident, that which corresponds to it in the opposite jaw, being no longer worn away by use, increases to a very great length. Their feet are furnished with toes and nails, and their hind legs are stronger and longer than their fore legs, so that frequently they leap better than they run. Of this order, among others, are the beaver, the squirrel, the dormouse, the marmot, the hamster, the mouse and rat, the jerboa, the various species of hare and rabbit, and the porcupine.

The Beavers (Castor fiber) have been long celebrated for the value of their skin as an article of commerce, and for the wonderful sagacity and forethought which they exhibit in the construction of their dwellings. Their cutting teeth are very strong and sharp, and they are able, with them, to fell lofty trees.* They are possessed of a large, long, and broad tail, almost oval in its shape, and covered with scales. It has been supposed that they used this as a kind of trowel, to lay on the mud and clay of which their dikes are partly built. But it has also been sometimes asserted that the tail was only of use as an instrument for swimming. They are aquatic animals, and construct themselves habitations upon waters which are sufficiently deep never to be frozen to the bottom, preferring running streams upon which the trees they cut, can float down to whatever spot they have chosen. Here they build a dam for the purpose of preserving the water always of a convenient depth, and construct their huts or cabins. Of their skill, sagacity, and intelligence, a more particular account will be given hereafter. But, although so wonderful in these respects when united in a society, they are, for the most part, helpless and timorous animals when living separately; a

* In felling a tree, several beavers are engaged at once around its trunk, and they gnaw it carefully in such a part of the circumference, as will cause it to fall in a direction convenient for their purposes. An observer of them relates, that he witnessed three beavers occupied in cutting down a tree; that, after a certain period, one of them left the two others, and went to a considerable distance, where he quietly watched their operations; and that, when the trunk was nearly divided, so that the weight of the branches was sufficient to bring down the tree, and the inclination was obvious on looking at its summit, he gave a smart stroke with his tail upon the water, as a signal to his companions, who immediately ran off with great expedition to escape the impending danger.—*Long's Expedition.*

beaver, although pretty large and strong, and armed with powerful teeth, if he meets a man alone upon the shore, sets himself down upon his haunches and cries like a child.

The Jerboa (Dipus sagitta) is a little animal of about the size of a rat, with a tail ten inches long, and legs of very unequal size, the hind legs being six inches, whilst the fore legs are but one inch in length. It cannot of course use them all at once without great difficulty, and moves principally by leaps, which are sometimes of five or six feet in extent, or by a hopping motion on its two hind legs, which resembles that of birds. Its fore legs it employs only as hands for the purpose of holding its food. It has been asserted that the ancient coney, mentioned in the Old Testament, was the jerboa, which inhabits Palestine to this day.

There is an American species of Dipus, called the Canadian Jerboa, which does not exceed two and a half or three inches in length. It has the same general characteristics as the animal before mentioned, and even exceeds it in the length of its leaps, which extend, if we may credit the accounts given of them, to the enormous distance of three or four yards, or nearly fifty times the length of its body.

The Hamster (Mus cricetus) is an animal larger and thicker than the Jerboa, and nearly allied to the common rat. It is distinguished by cheek pouches, which are capable of containing a very large quantity of food. When empty, they are so contracted as not to appear externally visible, but when filled, they are stretched to an enormous extent, and are capable of containing a gill of grain. A hamster has been caught and dissected, that had stored in its pouches a quantity of beans, which, when taken out and laid in a heap, appeared to be thrice the bulk of its whole body. The Canada rat (Mus bursarius) is almost equally remarkable for the size of these receptacles.

Of the Alpine Marmot (Arctomys marmotta) some account will be given hereafter. There is another species, however, which deserves a short notice. This is the Louisiana Marmot (Arctomys ludoviciana) usually known by the name of the prairie dog, from a slight resemblance of its cry to the barking of a small dog. It is a sprightly and interesting little animal, inhabiting the country around the Missouri and Arkansas rivers, and is found in villages from a few acres to several miles in extent, which are called by the hunters, prairie dog villages. It lives in burrows, the entrance to which is in the summit or side of a small mound of earth, somewhat elevated, but rarely to the height of eighteen inches. This mound, particularly around the entrance, is trodden down like a pathway. They delight, in pleasant weather, to sport about the entrance of their burrows, and five or six individuals may be seen sitting on a single mound. When alarmed, if the object of terror be near at hand, they retreat immediately into their holes; but if at a distance, they remain for some time barking and flourishing their tails, or sitting erect to reconnoitre.

The Porcupine is covered with hard and sharp spines, which afford it a natural protection against the attacks of other animals. In this respect it resembles the hedge-hog, and, were external appearance alone regarded, would be arranged with it; but both its structure and its habits of life are different, and it is obviously intended for subsisting upon vegetable food.

V. *Edentata,* Toothless animals, so called from the absence of the incisive, and sometimes also of the canine and grinding teeth. Their toes are terminated by very large, thick, and strong claws, which approach in some degree to the nature of hoofs. All the animals of this order are likewise remarkable for a great degree of torpor, listlessness and indisposition to motion; but some more than others. The sloth, the ant-eater, and armadillo, are among them; and of each of these there are several species.

The Three-toed Sloth (Bradypus tridactylus) is an animal whose very aspect is painful and disgusting from its excessive ugliness and deformity. The expression of its countenance and its whole attitude, indeed, convey to the beholder the impression, that its very existence is a burden. It is of about the size of a cat. Its fore legs are much longer than its hind ones, and it drags the latter after its body, as if weary of carrying them. It creeps, in fact, almost with its belly upon the ground, and cannot advance more than fifty or sixty paces in a day. It climbs trees, and feeds upon their leaves and smaller branches; but such is its indolence, that, after having despoiled one tree of its foliage, it endures the pangs of hunger a long time, before it removes to another, and usually consumes a day or two in ascending or descending. Sometimes indeed it has been known to suffer itself to fall to the ground, rather than undergo the labour of coming down by the trunk.

The Armadilloes are principally remarkable for their crustaceous shell or covering, which invests them like a suit of armour. This coat of mail is composed of several pieces, and marked by bands, the number of which serves to distinguish the different species from each other.

The Ant-eaters are totally destitute of teeth, but are furnished with a long slender tongue. This they thrust into the habitations of ants and termites, and draw it back covered with these animals, which adhere to it by the thick, viscid saliva, with which it is covered.

The animals of this order are principally found in the warm parts of the American continent.

VI. *Ruminantia.* This order is one of the most distinct and well marked among the Mammalia. They have generally eight incisive teeth in the lower jaw; but, except the camel, they have none in the upper; their place being occupied by a firm callous projection. They are commonly also destitute of the canine teeth. The grinders are always adapted for the mastication of vegetable food. They have neither toes nor nails, but, instead of them, each of their feet is terminated by a double hoof, which has the appearance of a single one cut into two. Hence they are called cloven-footed. Their fore feet being thus deprived of the instruments of feeling, are only capable of being used, like the hind ones, for walking; and consequently they are not possessed of that freedom of motion in the shoulder-joint, which is observed in the animals previously described. Examples of this order are found in the camel, lama, antelope, musk, deer, ox, sheep, and goat.

The most distinguished attribute of the ruminating animals, and that which gives to them their name, is the power of bringing their food up into their mouths, after it has been once swallowed, for the purpose of masticating it a second time. This power depends upon the structure of their stomachs, of which there are four. Of these the three first are so situated that the aliments may be made to enter either of them at pleasure, as the œsophagus terminates at a point where they all communicate together.

These animals usually feed upon grass and herbage; which substances, after being slightly chewed, are carried into the first stomach, called the *paunch*; there they undergo but little change, and are gradually transferred to the second stomach, a small, globular cavity, called the *bonnet* or *king's hood*, whose internal membrane is arranged in cells of an appearance like those of honey-comb. Having received the food, this stomach divides it into little rolls or pellets, which are successively carried up into the mouth, where they undergo a thorough mastication, and are then again swallowed and deposited in the third stomach. This, called *manyplies*, *tripe*, or *feck*, is distinguished by the numerous longitudinal folds of its internal membrane. It effects some farther change upon the alimentary mass. In the fourth stomach, however, into which it next passes, the principal work of digestion goes on. This answers to the single stomach of other animals; into it the gastric juice is poured, and here the function is finally completed. During rumination, the animal remains in a state of repose, almost of sleep; and this operation continues until the whole of the food previously swallowed has been subjected to it.

The ruminating animals have been more valuable to man, than any others. They are mild, docile, and easily domesticated. Their flesh furnishes us with a large proportion of our animal food; indeed there are few other quadrupeds that man is in the habit of eating. Several of them, as the camel, lama, ox, and rein-deer, are used as beasts of draught and burden. They require, comparatively, little care, attention, or protection, and are generally contented with the cheapest and coarsest food. The milk, fat, hair, wool, skins, horns, and feet of one species or another, are made use of, for nourishment, for clothing, or for various manufactures.

The Camel and Dromedary are singularly valuable in the countries where they are reared. Without them, in fact, the great deserts of Arabia and of Africa would be totally impassable. Their structure is every way adapted for the life which they lead. Their feet are very large, and divided, on their upper part, into two lobes, having each a hoof; but underneath are covered with an extremely strong, tough, and pliable skin, which unites the two together, and, by yielding in all directions, enables these animals to travel with peculiar ease and security over dry, stony, and sandy regions. They are capable also of passing several days without a supply of water; this power is probably owing to a number of large and extensive cells in the paunch, which they fill with water and retain for a considerable length of time, forcing it up into the mouth whenever occasion requires. It has been supposed that the camel had a fifth stomach for this purpose, but it was probably the enlargement of the paunch, which gave rise to the opinion. The Arabian camel, of which the dromedary is a variety, has one large bunch of fat upon his back, while the Bactrian camel has two. The dromedary is active and swift, and better adapted for rapid journies; the camel more slow and deliberate, and calculated for the transportation of baggage and merchandise.

The Lama has been called the camel of the new world. It resembles the camel in many particulars, but is much smaller, being of about the size of the stag. It is also called the Guanaco, and was the only labouring domestic animal possessed by the aboriginal inhabitants of America.

The American Bison, or Buffalo, as it is often, but improperly called, is an animal very similar to the domestic ox. It inhabits the pastures and plains of the western parts of the United States in almost incredible numbers. Thousands are seen at once feeding in immense herds. In those parts of the country which they frequent, travellers report that their paths leading to and from springs and pools of water, are as common and as well beaten, as the roads of a populous district. They are gradually retiring before the settlements of the civilized inhabitants, and will probably in time become nearly exterminated.

The Camelopard, or Giraffe, is the most lofty of all quadrupeds. It is remarkable for the great length of its fore legs, shoulders, and neck, which raise its head to an elevation of seventeen or eighteen feet, whilst, at its tail, it does not exceed half that height. Its colour is white, spotted with brown. It is a mild, gentle, and somewhat timid animal, and is very fleet and graceful in its motions. It feeds principally upon the foliage of trees, and inhabits only the centre of Africa.

All the ruminating order, except the camel, lama, and the musks, have horns. In animals of the deer kind, they are, with some exceptions, confined to the males. They are of a hard, solid, bony substance, generally large and branching, and are periodically cast off and renewed. In the sheep, the goat, the ox, and the antelope, they are permanent, are hollow, and increase yearly in size; whilst in the camelopard they are short, conical, and always covered by the skin of the forehead, which extends over them, and by a quantity of thick bristly hairs.

VII. *Pachydermata.* This order embraces all the animals with hoofs, which do not ruminate. They present a greater variety than the ruminating animals, and are called Pachydermata, because they are commonly possessed of a thick and tough skin. They have generally incisive teeth in both jaws, and often canine teeth or tusks of very great size. Of this order are the elephant, the hippopotamus, the tapir, the stag, the horse, the ass, &c.

The Elephant has, properly speaking, five hoofs on each foot, but they are so much enveloped by thick and callous skin, as to be scarcely observable. It is destitute of incisive teeth in either jaw; and, in place of the canine teeth in the upper, is furnished with two large tusks, which sometimes attain to an enormous size. These, which furnish the ivory of commerce, are used by the animal for tearing off the branches of trees, upon which it feeds, and sometimes as instruments of attack and defence. From the shortness of its neck, and the clumsiness of its head and jaws, the elephant is incapable of taking up its food or drink from the ground with the mouth, like other animals. This difficulty is obviated by its trunk or proboscis. This is a long and flexible organ, composed of an almost infinite number of little muscles, which contract and extend it at the animal's pleasure, and move it in every possible direction. It is in fact a prolongation of the nostrils, and is endowed with the senses of smelling and feeling to a great degree of perfection. There is at its extremity a cavity of a cuplike form, into which open two canals that run through its whole length, and serve for the transmission of air and for drawing up water. At the upper edge of this cavity or cup, is a small, fleshy appendage, somewhat resembling a finger in shape, which by being opposed to the surface of the cup, as the fingers are opposed to the palm of the hand, enables the animal to make use of its trunk as an organ of touch. It is nearly equal in this respect to the hand of the apes. From its length and flexibility it is capable of being bent double, and its extremity inserted within the jaws which are below, at its base; and in this way the animal's food, being taken up by the trunk, is conveyed into the mouth; whilst its drink, being first sucked up into the cavities of the trunk, is injected with considerable force through the apertures of the nostrils into the throat.

There are two species of elephant; the Indian or Asiatic, which inhabits the southern parts of Asia and the Indian isles; and the African, found in Africa, from the river Senegal to the Cape of Good Hope.

The Great Mammoth, an animal whose bones only have been discovered, the species itself having become extinct, resembled the elephant in many respects. It has been ascertained from the remains which have been found, that this animal possessed a trunk, tusks, and feet, similar to those of the elephant, and was of an equal size, but still more heavy and unwieldy. Its remains have been discovered in great abundance in North America, but rarely in any other part of the world. The bones of a smaller species have been found on the eastern continent.

The Hippopotamus, or River Horse, inhabits principally the rivers of the south of Africa, but was formerly known upon the southern extremities of the Nile. It is sometimes found ten or twelve feet in length, and six or seven in height. It has two very large tusks in the under jaw, which are partly concealed by its projecting snout and lips. These tusks are used by dentists for the manufacture of artificial teeth. It is a heavy, stupid, and ferocious animal; its body is thick, massy, and clumsy; and its legs are so short that its belly almost drags upon the ground. It subsists upon roots and other vegetable substances, and frequently creates great devastation upon the fields of millet, corn, rice, sugar-cane, &c. It walks with great ease at the bottom of the water, though obliged occasionally to rise to the surface for breath. An attack upon it while in the water is dangerous, since when wounded it becomes exceedingly furious, and often tears to pieces the boat of its aggressors.

Of the Rhinoceros there are several species. The one-horned rhinoceros is somewhat larger than the hippopotamus, and is equally stupid and ferocious. It has one large and solid horn, three feet in length, projecting from its snout. It frequents moist and marshy grounds, and feeds upon herbs, roots, and branches of trees. The other species have two horns, and are generally similar in form and habits of life.

The Tapir is the largest quadruped of South America; it is of about the size of an ass, and inhabits marshes and low grounds. Its nose terminates in a short and moveable trunk, which bears a distant resemblance to that of the elephant. It subsists entirely upon vegetables, and is of a gentle and timid disposition.

From the Wild Boar is derived the domestic Hog and all its varieties. The wild animal is extremely violent and ferocious, and is armed with much larger and stronger tusks than the domestic. All the numerous varieties of form, size, and colour, which are observed among hogs, are to be attributed to the various circumstances to which they are exposed in their domestic state.

Under this order are included the Solipeda or *single-hoofed* animals, in which the whole foot is enveloped in a single hoof. Of these, the most celebrated is the horse, one of the most beautiful and noble of all quadrupeds. These animals are distinguished, beside the formation of their hoofs, by the possession of six incisive teeth in each jaw; and, in the male, of two small canine teeth in the upper, and sometimes in the under jaw, which are wanting in the female. Between these and the double teeth or grinders, there is a vacant space, just corresponding to the angle of the lips, where the bit of the bridle is placed, by which man is enabled to guide and restrain them. Beside the horse, which is by far the most valuable and highly prized of all the domestic animals, this family embraces the ass, the zebra, the dziggetai, a species between the horse and the ass in size, of a light bay colour, inhabiting the central deserts of Asia, and the Couagga, an inhabitant of Africa, resembling in shape the horse, but, in stripes of dark and white colours, the zebra.

All these animals are found naturally in the wild state, except the horse. They are gregarious animals, live in immense herds, and subsist entirely upon vegetable food. Even the horse, in Tartary and America, is found free from the dominion of man, collected into troops or companies, each of which is led and defended by an aged male. But in all such cases it has been proved that the wild animals are the descendants of individuals who have been set at liberty by their masters, or who have escaped from them. Different breeds of horses differ very much, as is well known, in their colour, size, speed, shape, strength, and many other qualities which render them more or less valuable. These differences depend very much upon the care which is taken in rearing the young. The most beautiful, if suffered to become wild, begin soon to deteriorate, and give birth to a progeny destitute of elegance and symmetry. The horse in the wild state has a large and clumsy head, rough and frizzled hair, and an awkward and disagreeable form; so different indeed is he from the domestic animal, that we can hardly recognise him as being of the same species with the noble and graceful creature that we are accustomed to behold.

VIII. *Cetacea.* The whales are usually confounded with the class of fishes, which they resemble in many particulars of external appearance, as well as in the circumstance of residing always in the water. In point of structure, however, they clearly belong to the class Mammalia, since they breathe air, by means of lungs, are warm-blooded, produce their young alive, and nourish them with their own milk. Instead of fore feet, they are furnished with fins or oars, which, however, are supported by bones similar to those of the fore feet of quadrupeds. They have no hind feet, but their body terminates in a thick tail, which supports a fin or oar. This fin is horizontal, whilst that of fishes is vertical.

A few of the Cetacea are herbivorous, and are consequently obliged frequently to leave the water and crawl upon the shore in search of their food. Such are the manati, usually called the sea-ox and sea-cow, and the dugong. They have upon their fins the rudiments of claws, which are of service to them in their motions upon the land, and with which they are even able to carry their young. The mammæ, from which they nurse their young, are upon the chest like those of the human species; and they have, around the face, a growth of hair which resembles in a slight degree that of man. Hence, the appearance they present when the upper part of their bodies is elevated above the water, bears some resemblance to that of mankind, and they have consequently been called sea-apes. It is probable that these animals, being seen by the credulous, the ignorant, the timid, or the superstitious, gave rise to the ancient fables of the tritons and syrens, and, in modern times, to the various unfounded stories of mermen and mermaids.

The remainder of the cetaceous animals, such as the whale, porpoise, grampus, narwhale, and dolphin, are distinguished by a peculiar construction, which has acquired for them the common name of *blowers*, and which is rendered necessary by their mode of taking their prey. In taking into their very large mouths a great number of fishes, mollusca, medusæ, &c. at once, they would swallow at the same time large quantities of water, were there not some provision for getting rid of it. To effect this, the water is passed up through the roof of the mouth, into a cavity situated near the external orifice of the nostrils, from whence it is ejected, with considerable force, through a small aperture, called the blow-hole, on the upper part of the head. In some of the whales, as in the great Balæna, beside this arrangement, the mouth is furnished with rows of whalebone on each side, extended in the form of thin plates, and terminating at their edges in fibres or a sort of fringe, which serve the purpose of a sieve or strainer, to retain the large shoals of little animals that are taken in with the water, whilst at the same time the water passes through and escapes.

The Balæna mysticetus, or Great Greenland Whale, is an enormous animal, which attains to a length varying from sixty to seventy or eighty feet, and is nearly of as many in circumference. Its jaws are capable of being stretched twenty feet apart, and its plates of whalebone are sometimes twelve feet in length. It is covered, under the skin, by a layer of fat, which is often several feet thick, and yields, according to the different sizes of the animal, from twelve to twenty tons of oil. It used formerly to frequent the Atlantic coasts of Europe and America, but to such an extent has the pursuit of it been carried, that it has gradually been driven into the recesses of the northern seas.

There are other whales equal in length to this, but less valuable on account of their smaller circumference, their comparative leanness, and the difficulty of taking them.

The Spermaceti Whales are without the whalebone, and are remarkable for the disproportionate size of their heads. This size is owing to the existence of certain cartilaginous cavities upon their upper part, in which is contained the peculiar substance known by the name of spermaceti. These cavities are entirely distinct from that containing the brain, which is very small. They have little fat in other parts of their bodies, and it is on account of the spermaceti only that they are a valuable object of fishery. The odorous substance called ambergris, appears to be a concretion formed in the intestines of these whales, particularly when they are the subjects of certain diseases.

IX. *Marsupialia.* The Marsupial Animals have usually been distributed among those orders of the class Mammalia, to which they bear, in some particulars, the closest resemblance. Thus the Kanguroo has been enumerated among the Rodentia, because it resembles them in its teeth, and in the length and strength of its hind legs. The Opossum has been ranked among the Carnivora, and the Ornithorhynchus among the Edentata for a similar reason. But so peculiar and remarkable is the structure of these animals, and so singular their mode of nourishing their young, that it will be far more intelligible and interesting to the student of natural history, to have them placed together, and described as belonging to a single order.

The most remarkable circumstance with regard to the Marsupial animals, is the premature birth of their young, and the exceedingly unformed and imperfect state in which they are brought into the world. They are incapable of motion, and scarcely exhibit even the rudiments of limbs or other external organs. Their mouth is simply a round orifice without distinction of parts; but by means of it, they attach themselves to the nipples of the mother, and there remain immoveably fixed, deriving their nourishment from them, and gradually improving in shape, and increasing in size, until they are as completely formed as other animals are at the time of their birth. So small in proportion are the young when first born, that the Kanguroo, which when full grown is as large as a sheep and weighs one hundred and fifty pounds, is at its birth no more than an inch in length, and weighs only twenty-one grains.

Generally, the female is furnished with a duplicature of the skin of the abdomen, which forms a kind of bag, covering the nipples, in which it places its young and preserves them during the period of helplessness. Frequently, indeed, even after they have acquired strength to leave this pouch, they retreat into it upon the approach of danger. Sometimes, in place of the pouch, there is simply a fold of the skin. The pouch is supported by means of two bones attached to those of the pelvis, from which proceed muscles that open or contract its mouth like the opening of a purse. These bones are found also in the male, and in those species which have not the complete pouch; and are always an indication that the animal belongs to this order.

The Opossum is as large as a cat, and covered with a thick fur of a dingy cast. It hunts after birds and their eggs, and is destructive to poultry. It is found in many parts of the United States. When pursued and overtaken, it feigns itself dead, and will give no signs of life during the presence of its assailant, although tortured to a great degree. Its young, which are sometimes six or seven in number, are exceedingly minute; and, although blind and without limbs, find their way by a sort of instinct to the nipples, and adhere to them till they have attained the size of a mouse, which is not until the fiftieth day, when also they first open their eyes. They continue to return into the pouch, until they reach the size of a rat.

The Phalangers are found in the Moluccas and New Holland. Their tails are long, covered with scales, and prehensile. They live upon trees, and subsist upon insects and fruit. When any one approaches them, they suspend themselves by the tail, until they fall, through mere fatigue, to the ground. The Phalanger volans, or Great Flying Opossum, is of about the size of a common cat, and resembles in many respects the flying squirrel. Like that animal, it is provided with the power of extending the loose skin of its sides when it stretches out its legs, so as in some measure to buoy itself in the air, whilst leaping from one tree to another. It can leap in this way to the distance of a hundred yards.

The Merian Opossum is remarkable for its method of carrying its young. It conveys them on its back, where they fix themselves by twisting their tails closely about that of their parent, and clinging with their claws to its fur.

The Kanguroo is the largest animal of this order, and the largest quadruped which has been discovered in New Holland. It is sometimes six feet in height, and is distinguished by the great disproportion in length between its fore and hind legs; the former being only one foot and a half long, but the latter three feet and a half. In consequence of this, they cannot walk upon all fours without difficulty, but leap with great power, and to a prodigious distance, sometimes twenty feet, and to the height of nine feet. They sit upon their hind legs whilst at rest, seldom using the fore legs except for supporting themselves when stooping to drink, for conveying food to the mouth, and for digging in the earth. But although disproportionately long, as has just been observed, when full grown, the hind legs of the Kanguroo at birth are not so large or so strong as the fore legs, which are more necessary, in order to favour the motions of the little animal while in the pouch.

The Ornithorhynchus has not the pouch, like the opossum and kanguroo, but has the marsupial bones, and is therefore to be enumerated under this order. It is a most singular and anomalous animal, and approaches in some particulars to a resemblance to birds. Its mouth is very much like the bill of the duck; it has a bone resembling the fourchette or wishing-bone of birds; it has no nipples for nursing its young, and a doubt still exists if it be not oviparous. This is the belief of the inhabitants of New Holland, who assert that it lays two eggs; and the dissection of the animal has led to the opinion that the eggs, if not laid, are hatched within the body of the parent, by its own heat, but just before the birth of the offspring. The male has, upon each of its hind feet, a spur, perforated by a small canal, through which, it is said, it can eject a poisonous fluid when it inflicts a wound. It is an aquatic animal, inhabiting the rivers and marshes of New Holland. Its feet are webbed to adapt it for swimming.

SECTION III.

Class II. Birds.

Birds being intended for flight, nature has adapted the structure of their organs to this purpose. Their anterior extremities, being designed to support them in the air, serve none of those purposes to which they are applied in quadrupeds; and they therefore invariably stand and walk upon two feet only. The neck is always long, and capable of a great variety and extent of motion; and the mouth, being furnished with a hard, horny beak, is without teeth. The breastbone is very large and strong, in order to support the powerful action of the wings, and has in front a large projection, in shape like a keel, that serves for the attachment of the strong muscles which put the wings in motion. The wings are composed of nearly the same number and kind of bones, as the anterior extremities of quadrupeds, and are covered with long and wide feathers or quills, so arranged as to be capable of acting upon the air, raising the animal from the ground, and conveying it about from place to place. The tail is also furnished with feathers that may be stretched out in the form of a fan, and serve to balance and direct the flight. The feet are furnished generally with four claws, but sometimes with only three. The bones of the leg and thigh resemble very nearly those of quadrupeds.

The heart of birds is constructed, like that of the Mammalia, with four cavities, two auricles and two ventricles. They have of course a double circulation, one through the lungs, and the other through the body. Their lungs, however, are arranged differently. They are fixed against the back and sides of the body, and covered by a membrane which, being perforated by many small openings, permits the air to enter into them, and likewise to pass into several cavities situated in the chest and belly. It even extends into the interior of the bones, and, by thus pervading various parts of the body, not only exercises very extensively its peculiar influence on the blood, but also renders the whole body lighter and better adapted for flight.

The organs of digestion also are somewhat varied. As birds cannot chew their food, a provision is made to supply this defect by means of the structure of their internal organs. The food is carried first into the crop, which appears to be merely an enlargement of the œsophagus or gullet, at the bottom of the neck, where it is softened by a liquor poured out from the internal surface of this cavity. It is then carried into a membranous sack, called the *ventriculus succenturiatus*, where it is further macerated and soaked; and from thence into the gizzard, which is composed of two very strong and firm muscles united by radiated tendons, and lined on its inside by a rough cartilaginous membrane. In this organ the food is powerfully acted upon, and is triturated and ground up into a substance resembling that prepared by the teeth and stomach of the Mammalia.

This structure, however, is not fully carried out in all birds. It exists in its most complete state in those which are granivorous, or which live upon fruits, seeds, &c.; but in the carnivorous birds, or those which feed upon flesh or fish, the dilatation of the œsophagus or gullet, constituting the crop, is very small or altogether wanting; and the gizzard is a thin and weak organ, hardly to be distinguished from the second or membranous stomach. This is a difference corresponding to that which has been described as existing in the Mammalia; among which those feeding upon vegetable food are provided with powerful and extensive organs of digestion, whilst in those living upon animal food they are comparatively weak, and limited in extent.

The sight of birds is very perfect. They possess the power of seeing objects distinctly, when very remote. Birds of prey are particularly remarkable for the very great distance at which they perceive their prey, and the accuracy with which they direct their flight towards it. Besides the upper and under eyelids, birds have a third, which is semitransparent, and serves the purpose of protecting the eye from the contact of external bodies, or from too powerful light, whilst at the same time it does not prevent them from distinguishing the objects around them. This membrane is situated at the inner angle of the eye, and is drawn over the globe of it, like a curtain, at will. It is by means of this protection, that the eagle is enabled to look steadily at the sun.

The senses of hearing and smelling are also possessed in considerable perfection by birds; the former more particularly by the nocturnal, and the latter by those feeding principally upon carrion, the scent of which they are thus able to trace, to an immense distance. Their tongue being chiefly of bone or cartilage, they have little delicacy of taste; and the sense of touch, judging from the structure of their claws and beak, which would be the organs for its exercise, must be exceedingly imperfect.

Most birds construct nests, and some of them with much care, labour, and ingenuity. In these they deposit their eggs, and hatch them by the heat of their own bodies. Some few lay them upon the sand, and leave them to be hatched by the heat of the sun. Their care and affection for their young are well known, and, in providing for and protecting them, they exhibit many indications of sagacity or of feeling. They are capable of some slight improvements by education and imitation, but are, on the whole, in this respect decidedly inferior to quadrupeds. The class of birds is divided, according to their structure and habits of life, into six orders.

I. *Accipitres*, or Birds of Prey. These correspond, in many respects, with the carnivorous animals among quadrupeds. They are distinguished by their strong, hooked beaks, and their crooked and powerful talons, by means of which they are enabled to prey upon other birds, and even upon some of the smaller quadrupeds and reptiles. They are divided into the diurnal and the nocturnal. The diurnal include the vultures, eagles, falcons, hawks, buzzards, and kites. The vultures are heavy and ferocious birds, feeding principally upon carrion. They are so voracious, and fill themselves to such an extent, that they become quite stupid and inactive, and during digestion a fetid humour distils from their nostrils. The eagles, falcons, &c. prefer living animals for their food, and never prey upon carrion, unless driven to it by hunger. The number of their species is very great, and they are observed to vary considerably in their plumage, according to their age and other circumstances. The females are generally a third part larger than the males, and are likewise superior in beauty of shape and plumage. Hence the latter are often called tercels or thirds, from their inferiority in size.

These birds are generally fierce and difficult to tame, but in former days, the hawk and the falcon were educated with great care, and trained so as to be employed as assistants in hunting.

The nocturnal birds of prey include only the different species of owl. They are destitute of the dignity and beauty which distinguish the diurnal. They have very large heads, which are sometimes surmounted with feathers that give them the appearance of being horned. Their eyes are very large, and, unlike those of most other birds, are directed forwards, and surrounded by a rim or circle of projecting feathers. Their structure is calculated to admit so much light, that the full rays of the sun dazzle and blind them; and they are capable of seeing only in the twilight or evening. The owls are awkward and clumsy in their motions, and their wings are too short and weak for long flights. They prey upon mice and other small quadrupeds, upon birds, and insects.

II. *Passeres*, or Sparrows, form the most extensive and numerous order, embracing a very great variety of species, which differ so much among themselves, as to be hardly capable of an intelligible description, common to them all. To this order belong those species which are most celebrated for the sweetness and harmony of their notes; and in general the organ of voice is in them larger and better formed, than in any others. Among them are some that have a sharp, pointed beak, and feed upon insects, such as the blackbird, the robin, the nightingale, and the linnet; and others with a short, flat beak, and wide mouth, which enable them to catch and swallow insects, while upon the wing. These migrate during the winter; among them being the swallow, the martin, and the salangane, (Hirundo esculenta,) a species whose nests, made of a gelatinous substance, probably the spawn of fishes, have been celebrated for their nutritious and restorative qualities. Some of this order have a strong, conical beak, feed upon seeds, and devour great quantities of cultivated grain; as the lark, the titmouse, the yellowhammer; and some are larger birds, as the crow and the magpie, which feed also in part upon grain, but are fond of flesh, and will sometimes take and destroy mice and other small animals.

The Birds of Paradise and the Humming Birds are also of this order. The birds of paradise have been celebrated for the splendor of their plumage, and the profusion of long feathers with which different parts of their bodies are adorned. It was formerly believed that they were destitute of feet, and never alighted upon the earth, but were always supported in the air by their long plumage. This mistake was caused by the mode of preparing them for sale, adopted by the natives of the countries they inhabit, who always deprived them of their feet and wings.

The Humming Birds are the smallest of the class of birds, and at the same time among the most beautiful. Their necks are clothed with small scale-like feathers of a peculiar structure, and a brilliancy almost equal to that of precious stones. They have a long and slender beak, and a long tongue divided into two filaments, with which they suck the nectar of flowers. They feed also upon insects. Their wings are exceedingly powerful in proportion to the size of their bodies, and they fly, comparatively, more rapidly than any other birds. They have the faculty of balancing themselves, by means of their wings, as easily as some insects, and are thus enabled to remain stationary in the air, whilst they thrust their beaks into flowers, to possess themselves of the contents. The rapid motion of their wings occasions the buzzing or humming noise with which their flight is accompanied. The smallest species of humming bird is found in South America and some of the West-Indian islands. It does not exceed an inch and a quarter from the extremity of its beak to that of its tail.

III. *Scansores*, or Climbers. This order includes those birds that have the external toe upon each side turned backward, which enables them to grasp substances more firmly with their claws, and affords them a more sure support, than other birds. This structure adapts them for climbing, as they can cling with considerable force to the rough bark and branches of trees. Hence all birds with this form of the feet, are of this order, although, strictly speaking, all of them do not climb, whilst some, belonging to other orders, and without this provision, do.

The birds of this order generally build their nests in the holes of decayed trees. Their food consists of insects, fruits, or seeds. Among them are the woodpecker, the cuckoo, the toucan, the parrot, &c.

The Woodpeckers are strongly characterized by a long, straight, angular beak, narrowed into a wedge at its extremity, and thus fitted for piercing and splitting open the bark of trees;

and by a long and slender tongue, covered towards its tip with spines or bristles which are turned backwards, and coated with a thick, viscid secretion. They run in every direction around the trunks and branches of trees, striking them with their beaks, and thrusting their tongues into the holes and clefts they find in the bark, for the purpose of drawing out worms and the larvæ of insects, which constitute their food.

The Toucan is principally remarkable for the enormous size of its beak, which is almost as large and as long as its whole body. It is of a light, cellular structure, and furnished with a long tongue, strait, and armed on each side with barbs like a feather. The toucans live in small flocks in the warm parts of America. When they have seized their food, they throw it into the air and catch it in their beaks, in order to swallow it with more ease, as they are incapable of masticating it.

IV. *Gallinaceæ*, the Gallinaceous birds. Of this order are the peacock, the turkey, the common fowls, the pheasant, the partridge, the quail, the pigeon, &c. Among them are nearly all those birds which have been domesticated, and are raised in poultry-yards. Their wings are short and weak, and of course they are not constructed for long continued flight; but they are capable of running with considerable rapidity. They have a large crop and a very powerful gizzard, their food consisting principally of hard grain. Their flesh in general furnishes excellent food. The males are distinguished by a stately gait, and frequently by a tail ornamented with long feathers. They do not live in pairs; their eggs are very numerous, and are laid in nests built of chaff or straw upon the ground. Their young are generally able to run about as soon as hatched.

The Pigeons form in some particulars an exception to the general characteristics of the gallinaceous birds, and approach to a resemblance to the Passeres. They fly very well, live in pairs, build their nests upon trees or in the clefts of rocks, and produce seldom more than two eggs at once. They nourish their young by bringing up from the crop the food partly digested, with which they feed them. The most remarkable species among them is the crowned pigeon of the Molucca islands, which is equal in size to a turkey. Its voice is exceedingly loud and harsh, and is said to have frightened sailors who landed on the islands it inhabits, by its resemblance to the yells of the savage natives.

V. *Grallæ*, the Waders, otherwise called Shore birds. They are distinguished by their very long and naked legs, which permit them to wade to a considerable depth in the water without wetting their feathers. The length of their neck and beak corresponds to that of their legs, and they are consequently able to search in the sand and mud at the bottom of the water for their food, which consists of fishes, reptiles, and worms. All birds with this structure of the legs are ranked among the Grallæ, although some of them are not, properly speaking, waders in their habits. To this order belong the ostrich, cassowary, flamingo, heron, spoonbill, plover, rail, woodcock, oxeye, yellowleg, &c. The greater part of them are possessed of strong wings and fly well, but the ostrich and cassowary, as is well known, are striking exceptions. They are almost incapable of flight, but run with immense rapidity. The ostrich inhabits the sandy deserts of Africa, attains to a height varying from six to eight feet, and is at once the most lofty of birds, and the swiftest of all animals. When chased, it annoys its pursuers by throwing up gravel and stones behind it with its feet.

VI. *Anseres*, the Web-footed birds. Their toes are connected together by a web or membrane, which fits them for being used as oars. Indeed the whole structure of these birds is such as to adapt them for swimming. Their legs are situated far back upon their bodies, their feathers are thick, smooth, and oily, and their skin beneath covered by a layer of close down, which effectually protects them from the contact of the water. Their necks are of considerable length, a provision which enables them, while swimming upon the surface of the water, to plunge their heads down to the bottom in search of food. Most of them are capable of a lofty and long continued flight, as the pelican, petrel, cormorant, albatross, gull, wild goose and duck; whilst others, from the shortness of their wings, can scarcely raise themselves into the air, but are principally confined to the surface of the water, as the sea-diver, guillemot, penguin, awk, domestic goose and duck, &c.

SECTION IV.

Class III. Reptiles.

The class of reptiles, including the various kinds of tortoises, lizards, serpents, and frogs, have cold blood, and a circulation and respiration less perfect than those of the preceding classes, which have warm blood. In reptiles, only a part of the blood received from the body by the heart, is sent to the lungs to be subjected to the influence of the air; whilst the remainder, having been mixed with a portion which has undergone the change that takes place in respiration, is returned again into the circulation. The greater part of the animals of this class have two auricles to the heart, but only one ventricle; into the left auricle, the red blood from the lungs is poured, and into the right, the black blood from the body. From the auricles, the two kinds of blood are immediately transferred to the ventricle, where they are mixed together; and this mingled mass is, by the contraction of the ventricle, sent through two distinct vessels, in part to the lungs and in part to the body.

The vessels of reptiles, then, are not filled with pure red blood, like those of the Mammalia and Birds, but with an imperfect fluid, not so well adapted to give them a high degree of life and vigor. Hence, as the animal heat is always in proportion to the quantity of respiration, they are cold-blooded. Their lungs are not so large; their circulation is slower; they consume less air, and are capable of living for a longer time without it. They are, in general, sluggish and indolent in their habits of life, obtuse in their sensations, and slow in their digestion. In cold countries, they pass the greater part of the winter in a dormant state. Their brain is small, and their nervous system imperfect and of less influence than in the preceding classes. They produce their young by means of eggs, but take no pains themselves to hatch them. They have less intelligence, fewer faculties, and less instinct, than either quadrupeds or birds. They are arranged in four orders, viz.

I. *Chelonia*, the Tortoises, are distinguished by the peculiar structure of their ribs, sternum, and vertebræ. These are so arranged as to form a complete covering, consisting of an upper and under shell, joined at their sides into one, which permits only their head, tail, and four extremities to be extended without it. The upper shell is formed by the extension and enlargement of the ribs and part of the backbone; and the lower shell, by an alteration in the form of the sternum. Their other bones are not essentially different from those of other vertebral animals. Thus a part of their skeleton is in fact on the outside of their bodies. They have no teeth, but their jaws are armed with a tough, horny substance which supplies their place. Their stomach is simple and strong, their intestines are long; and they are capable of going a great length of time without food. All the various species of the turtle and tortoise belong to this order.

II. *Sauria*, the Lizards. This order includes a very considerable variety, and is composed of the crocodile, the alligator, the cameleon, the true lizards, and the dragons. The greater part of them have four feet, but a few are possessed of only two. They have nails and teeth, and their skin is covered with scales.

The Crocodile is the most celebrated animal of this order. It is from twenty to thirty feet in length, including the tail; and is covered with a coat of scales, which on the back form an armour proof against a bullet, and have an appearance like that of carved work. It deposits its eggs in the sand, where the greater part of them are destroyed by birds and an animal called the ichneumon. Their eggs resemble a good deal those of the domestic goose, and are of about the same size; the young, when first hatched, are of course exceedingly small in proportion to the parent animal. They are at first mild and innocent, and may be handled with impunity; but the full grown animal is both subtle and formidable. It lies in wait, covered from view amidst long grass, rushes, or projecting banks of rivers, until some other animal comes within its reach, which it seizes and swallows, and then retires to some secret recess to digest.

The Dragons are remarkable for the possession of a sort of wings, produced by the extension of the six first false ribs, which support a fold of the skin. These serve, like a parachute, to uphold these animals in leaping to the ground from any height, or in springing from branch to branch on the trees they inhabit; but are not sufficiently large or powerful to enable them to raise themselves from the earth.

To the Cameleon has been attributed the singular faculty of changing the colour of their skin, according to the colour of the substance on which they are placed, and of subsisting upon air. This belief has arisen from the extraordinary size of their lungs, which they are capable of distending with air to such an enormous extent, as to fill nearly their whole body and render their skin somewhat transparent. Hence they were said to feed upon air. In this state of distension and semitransparency, the skin becomes easily affected by every change in the circulation; and consequently a change of colour is produced by the varying wants and passions of the animal, which influence both the quantity of respiration and the tint of the blood.

A few animals of the lizard kind are remarkable for their very short legs, and long slender bodies, giving them the appearance of serpents with feet, for which they have sometimes been mistaken.

III. *Ophidia.* The serpents are distinguished by their long and slender bodies without limbs, and by the great extensibility of their jaws, mouth, and throat, which enables them often to swallow animals of greater diameter than themselves. They are always provided with teeth, which are sharp and bent backward.

They are divided, as is well known, into the venomous and those that are not venomous. The number of the latter kind is the greatest, and includes the largest animals. Among them are the great Boa constrictor, the Aboma, and the Anacondo, which sometimes attain the length of thirty or forty feet, and inhabit marshy and fenny places in the tropical parts of America. They attach themselves by the tail to the branches of aquatic trees, leaving their bodies swinging in the air, in order to seize upon animals approaching them, which they generally swallow whole. The Ular Sawa, or the great Python, is another serpent of the same kind and size, and inhabits the ancient continent. The smaller and less celebrated species are very numerous, and are distributed over every part of the earth.

The venomous serpents are generally armed with fangs for the specific purpose of infusing poison into the wounds they inflict. These fangs are situated in the upper jaw, and perforated by a small canal, which, opening on their extremities, gives passage to a fluid, secreted by a gland under the eye. When the tooth pierces the flesh of any animal, a portion of this fluid is injected into the opening, and produces effects more or less dangerous, according to the virulence of the poison and the kind of animal wounded. When broken or injured, these fangs are renewed, and when not employed, are hidden from sight by a fold or projection of the gum. The largest and most celebrated of these animals, is the rattle-snake of America. It is so called from a peculiar instrument at the end of its tail, denominated its rattle, which produces a slight rustling sound when it is shaken, and is intended to give warning of the animal's anger. This and the other venomous serpents are not malignant or ferocious in their dispositions, and seldom make use of their poison unless provoked.

IV. *Batrachia.* The reptiles of this order have only one auricle to the heart, into which the veins from the lungs and from the body both enter. In it are included the toad, frog, salamander, and animals of these several kinds. They are principally remarkable for a transformation which takes place in their offspring after leaving the egg. When first hatched, they are strictly an aquatic animal and capable of breathing and living only under water. They are furnished with gills like a fish; and have no legs, but are provided with a tail, which serves them as an instrument of locomotion. In this state they are seen by thousands, of a dark colour, with round bodies, swimming about in brooks and small ponds; and are known by the familiar name of Tadpoles. After a certain period, their form and structure are altered; their feet and legs grow and project from beneath the skin; their tail, their gills, and the covering of their head, fall off; they begin to respire by means of lungs; and become at once animals capable of breathing only in the air. This transformation is not, however, in all cases, complete. In two genera, the Proteus and the Siren, besides lungs, the gills are retained through life, and they are thus possessed of two distinct sets of organs of respiration.

SECTION V.

Class IV. Fishes.

Fishes being destined to inhabit only the water, are provided with organs and a structure adapted to the element in which they reside; and, since they cannot breathe pure air, of course some modification in the organs of respiration and circulation would be particularly required to enable them to perform those functions. The heart, in them, has only one auricle and one ventricle. The blood, coming from the body, is received into the auricle, and transmitted by means of the ventricle to the gills, which perform the same office as lungs. These are situated upon each side of the neck, and consist of semicircular arches of bone or cartilage, to which are attached membranes, divided into little fibrils or fringes, to which the blood is distributed, in very small vessels, after it comes from the heart. Over the gills a constant current of water is passed by the action of the mouth of the animal, which, by means of the air that it contains, exerts an influence over the blood circulating in them, and produces the same changes in it, as are produced in the lungs of other animals by the air they breathe. From the gills, the blood does not return to the heart, but is collected into one large artery which passes down along the spine, and is distributed to the different parts of the body, whence it is again returned to the heart by the veins.

The whole structure of fishes is as clearly designed to attain the end of motion in the water, as the structure of birds is intended for motion in the air. They are destitute of limbs, and their motions are effected by means of their fins and tail, which act upon the water like oars, either propelling the animal forward or moving it upward, downward, or to either side.

Fishes are covered with a thick, strong skin, and most of them with scales, which are arranged one over another in an imbricated form like slate or tiles on the roof of a house. Their bodies are also invested with a covering of thin slime or mucus, which defends them from the immediate contact of the water. Their forms vary exceedingly, and are much more numerous than those of the animals heretofore described. They vary also in size. Some are armed with strong, sharp spines; some with a sword or saw; and most of them with teeth. The latter however are not intended for the purpose of chewing, but merely for that of seizing and retaining prey, which is swallowed whole. A few are possessed of a very remarkable species of defence, which consists in the power of inflicting upon whatever living creature comes in contact with them, a powerful electrical shock. These shocks are so powerful, that, in South America, horses driven into the pools which some fishes of this kind inhabit, have sometimes been stunned and even killed.

Fishes have but a small brain. They have the senses of seeing, hearing, smelling, and tasting. That of touch they probably possess but imperfectly, as they have no organ which seems intended for its exercise except the snout and mouth, and, in some species, a sort of feelers, growing around the mouth. Their skeleton is constructed of bones, generally softer and less earthy than those of other animals, and indeed in some they are entirely cartilaginous. Their stomach and intestines are formed upon the same general plan with those of other vertebral animals, and digestion is carried on in the same general way. They feed principally upon other fishes, upon worms, and shellfish. They are long-lived, attain to their full growth slowly, and exhibit but few signs of intelligence or remarkable instinct.

Their constant residence in the water prevents that accurate knowledge of their character and habits of life, which would afford materials for a more copious detail. They are divided into orders and genera, according to certain differences in the formation, structure, and situation of their mouth, gills, gill-covering, fins, &c. But an account of them here would be of little use or interest.

SECTION VI.

Class V. Insects.

The animals of this class, although less complicated and perfect in their internal structure, than those of some of the following classes, are yet remarkable for a greater variety of powers, and a more wonderful display of instinct and intelligence, than any other of the invertebral animals; and they are, therefore, placed first among them in this description.

Insects are destitute of a heart, but instead of it they have a vessel or reservoir situated along the back, extending from one end of their bodies to the other, and filled with a transparent, viscous fluid. This vessel undergoes an irregular contraction, which is supposed to be analogous to the contractions of a heart. No branches have been discovered going off from it, and yet it is highly probable that this reservoir contains the blood or nutritious fluid of the animal, which is slowly conveyed, by absorption, to the various organs. Insects have no particular organ for respiration, but their bodies are penetrated in every direction by tubes, called tracheæ, which convey the air to every part. These tubes communicate externally by openings called stigmata. The blood therefore undergoes the changes wrought upon it by air, throughout its whole circulation. Instead of a brain and nervous system, they are furnished with two knotted cords running the length of their bodies, which perform the same functions. They possess the senses of seeing, tasting, smelling, and feeling; but organs of hearing, if they exist, have not yet been discovered.

Being destitute of any internal skeleton, insects are provided with a hard external covering, which serves to support their motions and protect their organs. The nature of this covering differs in different species; in some it forms a complete shell or case of a horny or shell-like substance; and in others it consists merely in a tough, muscular coat, divided into rings which surround the body.

The greater part of insects are winged, but some are not so. Those which are not winged, continue, during their whole existence, of the same form and structure as at birth. Those which are winged undergo certain metamorphoses, or changes of form, which will be hereafter described. They all have six legs, with the exception of the millepedes, which have always more; and the number increases also with their age.

The bodies of insects are divided into head, trunk, and abdomen. The head is attached to the trunk by a joint or articulation, which is moveable in every direction. It is destitute of a brain; but is furnished with a mouth, eyes, and two antennæ or feelers. These are a kind of filaments composed of joints, varying very much in form and length, probably designed as the organs of the sense of touch, or of sensations still more delicate and of a nature totally unknown to us.

The mouth of insects varies much in its construction according to the nature of their food. Some of them subsist only upon the juices of animal and vegetable substances, and have their lips arranged in the form of a tube or sucker; some of them are armed with a sort of lancet, with which they are enabled to pierce the skin of animals; some with a kind of beak; and others with a trunk or proboscis, which in the butterflies is capable of being rolled up in a spiral form. The insects which subsist upon solid substances, are provided with jaws, which generally act laterally instead of vertically, and serve to masticate their food. Beside these parts, many species are furnished with *palpi*, organs somewhat resembling the antennæ in structure and appearance, but whose office is to bring the food to the mouth and hold it while the insect eats.

To the trunk are joined the legs, and the wings when present. It is divided, in those that have only six legs, into three segments or divisions, to each of which one pair of legs is attached. The legs are composed of four parts, called the haunch, thigh, leg or shank, and foot; which resemble considerably the corresponding parts in the limbs of quadrupeds. They vary in different insects according to their habits and modes of life. Thus, in the grasshopper, the hind pair are very long and strong; in the aquatic insects, they are flattened in order to answer the purpose of oars. The wings differ much in kind and arrangement, as well as in number. Most of the winged insects have four, but some only two. They are generally thin, dry, membranaceous, and semitransparent. In the butterfly, the membrane forming the wing is concealed by a covering of small scales, which appear to be merely a loose powder, but are in fact fixed by small pedicles or stalks to the membrane itself. They give to those insects their beauty and variety of colour. The insects with one pair of wings have underneath them two cylindrical projections terminating in a knob, which seem as if they were the rudiments of a second pair. These have been called balancers or poisers, from being supposed to aid them in preserving an equilibrium during their flight. Between them and the wings themselves are found small membranous scales, one upon each side, against which the balancer strikes with great rapidity whilst the insect is in motion, and causes that buzzing which is then observed. In the various kinds of beetle and other similar insects, the upper pair of wings is of a coriaceous or bony texture, and serves merely the purpose of a case under which the other pair is folded up and protected. In others, as in the grasshopper, the locust, &c. the upper pair is less hard, and has rather the consistence and texture of vellum.

The abdomen forms the hinder part of the bodies of insects; it contains the organs of digestion, and is the part from which the eggs of the insect are produced. It is divided into a number of rings or segments. In some, it is furnished with a kind of perforator or auger, with which various substances are bored in order to admit their eggs. In many it is terminated by a sting, as in the wasp and bee, and in others by a forceps, a bristle, or a kind of claw. They display much instinctive intelligence in the deposition of their eggs, placing them in situations best adapted to the nourishment and preservation of their young when hatched, and in some cases even providing food for their immediate wants when they first come into life.

The greater part of insects, as has just been remarked, after leaving the egg, undergo certain changes of structure and form, before arriving at their perfect state. These changes are called their metamorphoses. They differ in number in different kinds of insects.

To take the Butterfly tribe for an example. From the egg of this insect is hatched an animal differing entirely from its parent. Its body is long and cylindrical, and divided into a great many rings. It is provided with a large number of very short legs, with jaws, and with several small eyes. It is familiarly known to us by the name of *caterpillar.* It lives in this state a considerable time, subsisting upon such food as is adapted to its nature. At length it casts off its skin, and appears in another form without limbs. It ceases to feed or to move. It seems to be totally without life. This is called the *chrysalis.* After a while, by examining it closely, the imperfect shape of the butterfly may be distinguished through its surface; and finally the envelope is broken, and the animal escapes. Its wings are at first short, weak, and moist, but they soon unfold to a greater size, and become strong; and the insect is in a state to fly. It has now six long legs, a spiral trunk, two antennæ, and eyes differing entirely from those of the caterpillar. In short, it is an animal totally different; and yet these wonderful changes are only the successive unfolding of parts contained one within another in the original embryo.

In the first state, the animal is called the *larva;* in the second, the *nympha* or *chrysalis;* and the third is called the *perfect state.*

A considerable proportion of the insect tribes pass through these three stages of existence. But many only undergo what is called a demi-metamorphosis. Their larva resembles the perfect insect, except that it is without wings. And the only change they experience, is, that in the nymph state they have the stumps or rudiments of wings, which finally, on casting their skin, are changed into complete ones. Such are grasshoppers and many kinds of bugs. Insects without wings undergo none of these alterations.

A more detailed account of the phenomena attending the metamorphoses of Insects will be found in a subsequent part of this volume.*

There are few vegetable substances which escape the depredations of insects, and sometimes their ravages produce very serious evils. Some good as well as evil, however, may be attributed to their agency. Many of them feed upon putrid animal or vegetable matters, whose effluvia might otherwise become dangerous or fatal. Others are made use of in medicine, in the arts, and sometimes even as food for man. They serve as nourishment for many species of animals. Beasts, birds, reptiles, and fishes, equally make them their prey ; and thus prevent their multiplication to such an extent as to prove a permanent evil to mankind.

It only remains to give some general account of the orders under which insects have been arranged, and the principles upon which philosophers have proceeded in making the distribution of them.

The divisions of Linnæus are founded upon the presence or absence of wings, their number, their texture, their arrangement, and the nature of their surface ; and upon the existence or absence of a sting. He forms seven orders.†

I. *Coleoptera*. The upper pair of wings in the Coleopterous insects consists of a crustaceous or horny substance. These cover and defend the other pair, which are of a more soft and flexible texture, and are folded beneath them. This is the most numerous and best known kind of insects ; and many of them are very remarkable for the singularity of their forms and the beauty of their colours. It includes the various insects known under the names of beetles, winged bugs, &c. They all undergo a complete metamorphosis.

II. The *Hemiptera* have likewise four wings ; but the upper pair is not of so hard a texture as those of the Coleoptera. They are more like fine vellum, and, at their extremities, terminate with a membranous edge which resembles the

* See chapter on the Transformation of Animals.

† This account of the classification of Insects, is taken principally from Smellie, who follows Linnæus, because, to the general reader, it affords, upon the whole, a clearer view of the subject, than could be presented in the same compass by following the later and more strictly anatomical methods of other naturalists.

substance of the under pair. They cover the body horizontally, and do not meet in a strait line or ridge, as they do in the beetles. Insects of this order undergo only a demi-metamorphosis. Among them are found the grasshopper, the cricket, the locust, the cock-roach, and many kinds of bugs.

III. The order *Lepidoptera* contains the various kinds of butterfly, sphinx, and moth. Those of the first kind fly in the day-time; those of the two other kinds only in the night. They all have four wings, the structure and appearance of which have been alluded to. Among them are some of the most beautiful and splendid of insects, and they form some of the richest ornaments of the cabinet of the naturalist. They all pass through a complete series of metamorphoses; and their larvæ, known under the name of worms or caterpillars, spin webs for their covering while in the chrysalis state. It is from the web, thus prepared by the silkworm for its residence during this dormant state of existence, that the silk of commerce is prepared.

IV. *Neuroptera.* This is another order with four wings. They are membranaceous, naked, and so interspersed with delicate veins, that they have the appearance of a beautiful network. The tail of the Neuroptera has no sting, but that of the male is frequently furnished with a kind of forceps or pincers. Of this order are the various species of Dragon-fly, large and well known insects that frequent lakes and pools of stagnant water, in which the female deposits her eggs; the Ephemera, insects which pass two or three years in the states of larva and chrysalis, but whose existence as winged and perfect insects is limited to a single day; and the Ant-lion and the Termites, the former celebrated as the destroyer of the common ant, and the latter for the ravages they make, in the state of larva, in some tropical countries. The Neuroptera do not all pass through a complete metamorphosis, a part of them undergoing only a partial change of form.

V. The *Hymenoptera* have four naked membranaceous wings, but they have not that delicate, netted structure, which belongs to the last order. The bodies of the females are terminated by a borer or perforator, or by a sting. These insects all undergo a complete metamorphosis; but there are, in the domestic economy and mode of propagation of some of the species, circumstances which excite our admiration and astonishment. The ant, wasp, and bee, belong to this order. They live in societies, greater or less in extent and number; and prepare habitations and nourishment for themselves and their offspring, with a forethought and provident care excelled only by those of man himself. In some of the tribes of insects of this kind, there is, beside the males and females, a third sort called neuters, as among the ants and bees. Sometimes the neuter, and sometimes the female, is without wings, and sometimes without a sting. A more particular account of these insects will be given hereafter. Besides the abovementioned, there is found in this order a variety of singular animals; and, among others, the ichneumon-fly and the saw-fly, which by means of their instruments for boring, in some constructed in the form of a saw, insert their eggs in the wood, leaves, and fruit of plants, or in the eggs, larvæ, or nymphæ of other insects.

VI. The *Diptera* have only two wings, but beneath them are the balancers or poisers, which have been already mentioned. Their mouths are frequently armed with lancets and suckers, by means of which they pierce the skin of animals and feed upon their blood. To this order belong some of the most troublesome and annoying of the whole animal creation, viz. the various species of gnat and gadfly, the musqueto, the common housefly, the horsefly, &c. They attack both men and other animals, and are found in almost every part of the globe. Their larvæ are deposited in the skins and intestines of brute animals, sometimes even in those of men, in putrid meat, in cheese, in manure, in water, in mud, &c. They pass through a complete metamorphosis.

VII. *Aptera*. In this order is included a great variety of insects that are destitute of wings. It is true that in the preceding orders are arranged many sorts of insects, which are destitute of wings; but they are so arranged, because, in their general structure and habits of life, they resemble the other members of the order. The Aptera, however, have no such resemblance, and are therefore placed by themselves. Some naturalists divide them into several orders, according to their natural connexions with one another; but this is not necessary here. Among them are found the millepedes, whose body is divided into a great number of rings, each of which serves for the attachment of one or more pairs of legs; the louse, of which there are many kinds which infest the bodies of men, inferior animals, and plants; the puceron, &c. Some of these animals cover the surface of plants so completely, as to produce the appearance of a diseased change of structure. The flea also belongs to this order, and is the only one that undergoes any metamorphosis. It passes through the three stages. Its power of leaping to a great distance is well known.

The family of the Arachnides or Spiders, is not always ar ranged among Insects, and, strictly speaking, their structure is different in some important particulars. We shall, however, give some account of them in connexion with the Aptera, among which they were included by Linnæus. This family comprehends, beside the common spiders, the scorpion, the tarantula, the crab-scorpion, the various species of mites, and the animal which has been supposed to cause the Psora or itch, by insinuating itself beneath the skin.

They are distinguished from all other insects by the absence of the antennæ. A part of them breathe like insects by means of tracheæ distributed throughout their bodies; while in the rest, the tracheæ open into pulmonary sacks, which answer the purpose of lungs. In the latter, there is found a well organized heart and a vascular circulation, which are absent in the former. They have generally eight legs, and are furnished with six or eight eyes, which enable them to perceive objects in several different directions at once. They are nourished generally by living prey, and are provided with means for securing and destroying it. The Spider effects this by means of the web that it spins, in the construction of which much ingenuity is often manifested. The threads of which it is composed, are produced from six little fleshy bunches, situated at the lower extremity of their bodies, which are perforated with an immense number of little holes. By means of their webs, many species of spiders, particularly when young, are able to transport themselves to a considerable distance through the air. In order to effect this, they ascend some eminence, and throw out a number of webs. These are raised up and carried along by the wind, and the animal, being buoyed up by them, is conveyed sometimes to a great height. In order to alight, they have only to disengage themselves from a part of their web, and suffer themselves to descend gradually to the ground. It is probable that they have recourse to this expedient, in part at least, for the purpose of catching insects for food. In autumn, the air is often full of the cobwebs which have been made use of for this singular mode of conveyance; and those who have ascended eminences for the purpose of observing this phenomenon, have frequently seen spiders floating by in the air, supported in the manner just now described.

Many branches of this family are exceedingly cruel and ferocious, not sparing even their own species. The bite of many of them is poisonous, particularly that of the tarantula and the scorpion. They undergo no metamorphosis, but shed their skins several times. A few receive an additional pair of legs at some time after birth.

SECTION VII.

Class VI. Crustacea.

The Crustaceous animals have been sometimes included in the class of Insects, to which they have indeed many strong points of resemblance. They deserve, however, a separate consideration, both on account of their size and importance, and of some anatomical differences of structure which will be pointed out. Among the most familiar examples of this class are the lobster, crab, crawfish, and what is usually called the horse-shoe.

They have articulated limbs, antennæ, and jaws, similarly formed to those of insects. But they breathe by means of branchiæ or gills, and have a regular double circulation; in which particulars they differ from insects. The blood which has passed through the gills is collected into one large vessel, that distributes it to the whole body. On its return from the vessels of the body, it is collected into another vessel situated near the back and performing in some measure the office of a ventricle, and is again sent to the gills. Their nervous system and the degree of sensation they enjoy, are not essentially different from those of insects.

They are covered by a pretty thick, firm shell, which envelops them completely. This serves for a shelter and protection to their soft parts, and also answers to them the same purpose, as an instrument of motion, that the internal system of bones does to the vertebral animals. As this shell is incapable of growth, it is occasionally changed, to make room for the constant increase in size of the animal. It is thrown off, and their bodies remain for a time entirely naked, and exposed in a soft and defenceless state. In this case the animal generally retires to some place of concealment and security, and remains till the shell is restored. This is done by the deposition of calcareous matter on the external membrane of the skin, which consequently becomes hard and firm, and finally takes the place of the old shell.

The Crustacea have always as many as six claws, and frequently more. The two anterior ones are often prolonged, enlarged, and armed with teeth, so as in some measure to act in assisting the jaws. Their antennæ, as those of insects, are probably intended to serve as very delicate organs of touch. They possess the sense of smelling, but naturalists have not been able to satisfy themselves in what organ it resides. The organ of hearing has been discovered. Their eyes are not placed loosely in a socket, but are fixed and immovable; and, to remedy the inconvenience which would result from this arrangement, they are, in some species, situated upon the end of a pedicle or stalk which is capable of motion in every direction.

The stomach of some of the crustacea presents a very singular and remarkable structure. It is exemplified particularly in the the crab, lobster, crawfish, and others of the same kind; and is found in no other animals of any class. Near the lower end of the stomach, where it begins to grow narrow, are situated a number of teeth, or substances of a bony nature resembling teeth, generally five in number. They are placed upon the opposite sides of the organ, and, being moved by muscles belonging to them, they grind up thoroughly the food past between them, which then goes out at the orifice into the intestines.

The animals of this class reside for the most part in the water. A few are found upon land. The former do not immediately die on being taken out of their natural element, but can live for some time in the air. They are generally carnivorous. Many of them furnish very delicious articles of food, although their flesh is ordinarily heavy and difficult of digestion.

SECTION VIII.

Class VII. Mollusca.

This is a large and extensive class, embracing a great variety of animals, whose structure, residence, and habits, are but obscurely and imperfectly known. Among them are the cuttle-fish, squid, oyster, clam, muscle, snail, and, in short, nearly all the testaceous animals, or shellfish, as they are usually called, although they have no resemblance to fishes, and do not all inhabit the water. As it respects their internal structure and organization, they are undoubtedly superior to the two classes last described; but in regard to intelligence and instinct, they are upon the whole inferior, and are not subjects of so much interest.

The Mollusca are destitute of bones and of articulated limbs. Their bodies are generally of a soft texture, and frequently, at first sight, appear to be little else than a simple mucous mass, without parts and almost without organization. Their muscles are fixed into the skin, which is naked, very sensible, and constantly moistened by a fluid furnished by its pores. The contractions of these muscles produce certain obscure and indistinct motions of their whole bodies, by means of which they are enabled to swim and crawl, or even seize those objects which are adapted to their nourishment. But as no part is supported by any solid foundation like the bones of vertebral animals, their motions are generally slow, awkward, and limited.

Their bodies are generally covered by a fold or reflection of the skin, which envelops them completely, and is called their mantle. In some species, the two folds of the mantle are united at their edges, so as to form a complete bag, in which the body of the animal is contained, opening only at one end by a sort of canal or snout; and in some, it extends in two opposite directions, so as to answer the purpose of fins or oars. Sometimes there is only this simple membranous covering; but more frequently there is a hard external shell, which serves as a retreat, into which the animal may withdraw itself, and which it can carry about upon its back in all its changes of place. These shells differ exceedingly in shape, colour, and texture, in different species; and among them are found some whose form, polish, and splendid tints place them among the most beautiful objects in nature.

The Mollusca have no brain nor spinal marrow. Their nervous system consists merely of a number of nervous masses distributed in different parts of their bodies, from which are sent out a great many small branches that mutually unite with each other. The principal of these, which is sometimes called the brain, is situated around the œsophagus, and envelops it like a collar. In a few species it is contained in a cartilaginous case. Their respiration is not uniform. It is generally carried on by organs resembling the gills of fishes, which are acted upon either by fresh or salt water; but, in some cases, air is respired directly from the atmosphere. The circulation is always double; that is to say, there is a passage of the blood through the respiratory organs, distinct from that through the rest of the body. This circulation is carried on by either one or more hearts. When there is only one, it is situated so as to receive the blood from the gills, and circulate it through the body. When there are two, the second is situated so as to circulate through the gills, the blood coming from the body. In some species there are three hearts, and in this case, as there are two sets of gills, a distinct heart is devoted to each. The blood in the Mollusca is thin, of a bluish white, and always cold.

The organs of digestion vary very much. Sometimes there are organs for mastication, and sometimes not. Some species have only a single stomach, and others have several; the structure of this organ, in some species, very much resembling that of the gizzard of birds. In some species there are four stomachs, which bear a great analogy to those of the ruminating animals, and have been supposed to answer a similar purpose. In the intestines there is as great a variety.

This class is divided into several orders, according to the general form and structure of the species composing it. A few of the most important particulars that distinguish them will be pointed out.

In the first order, containing the cuttle-fish, squid, nautilus, &c. the body consists of a sack formed by the mantle, enveloping all the parts except the head, which projects from it and is provided with a number of fleshy arms or feet, tapering towards their end, frequently of great length and of great power. These arms are capable of being moved in every direction, and are furnished with a large number of suckers in the form of cups, by which the animal can attach itself very closely to whatever object it embraces. They serve for swimming, for creeping, and for seizing prey. In all its motions, the head goes last, so that the animal in a manner pushes itself backward in whatever direction it wishes to move. Between the arms is placed the mouth, which is furnished with two strong jaws of a horny texture, and in shape resembling the beak of a parrot.

These animals have the power of ejecting a peculiar liquid of a black colour when in any danger, for the purpose of discolouring the water of the sea around them, and thus concealing themselves from their enemies. The cavity containing this liquid is situated in the abdomen, and is sometimes found in the very substance of the liver. It has been supposed, that the celebrated paint called Indian ink, is made by the Chinese from the inky fluid of some animal of this kind, (Sepia rugosa.)

Their eyes are large and perfect. They have an ear; but no organ for smelling has been discovered, although they probably possess that sense. Their nature is fierce and cruel. They are exceedingly voracious, and devour great numbers of fishes, and other aquatic animals.

Some of the animals of this order grow occasionally to an immense size. This is more particularly the case with the eight-armed cuttle-fish, (Sepia octopodia.) In the Indian seas, it is said to attain to such a magnitude, that its arms are nine fathoms in length, and the other parts of its body large in proportion. The natives hold it in great dread, fearing that it will lay hold of their boats, and drag them under water. They keep themselves provided with hatchets, to cut off its arms, should any danger arise from this cause.*

In another order, which includes the snail and the greater part of cockles, the foot or instrument of motion, is placed under the belly of the animal, and consists of a fleshy plate or disk, protected underneath by a layer of a horny or calcareous substance, which, when the animal retreats into its shell, serves to close up its opening. Their mantle is fixed upon the back, and covers more or less of the body, the head also being partly enveloped by it. The mouth has generally a few tentacula or feelers beneath it, but they are sometimes wanting. The eyes are very small, sometimes fixed to the head and sometimes situated upon the end of the tentacula;

* An account of an enormous animal, which was probably of this kind, is found in the works of Pliny, who cites it from a writer named Trebius. This animal made its appearance on the coast of Carteia, and was in the habit, during the night, of robbing of their contents certain reservoirs of salt-fish, which were situated near the seaside. Its depredations were not prevented by a row of stakes which were so planted as to intercept communication with the sea. It was found that the animal made use of a tree which grew near the stakes, to assist it in climbing over them; and it was finally attacked, while in the reservoir, by a number of dogs and men. It made powerful resistance, and lashed the dogs smartly with its arms, but was finally killed. Its body was as big as a hogshead; its arms, called its beards, were as big as a man could clasp, and thirty feet long; and its cups or suckers held four gallons each. It weighed 700 pounds. The Kraken is supposed to be an animal of the same kind.

but they are also sometimes wanting. These animals are almost always furnished with shells, which serve them as a residence.

The Mollusca of another order, including the oyster, the clam, the quahog, the muscle, and in short, all the bivalve shellfish, have no apparent head, but only a mouth surrounded by four tentacula, and situated beneath the folds of their mantle. The mantle is generally composed of two folds which inclose the body between them, as a book is contained within its covers. Sometimes the edges of the two folds are united together and form a complete sack. In the clam, this sack terminates in a long, double, fleshy tube, which is usually called the head of the animal, but in fact serves a totally different purpose; one of the tubes being for the entrance of the water which supplies the gills in respiration, and the other serving as the termination of the intestinal canal; and the mouth of the animal being situated at that part of the body which corresponds to the other extremity of the shell.

The Giant Clam (Chama gigas) is the largest of the Mollusca with a testaceous covering. Its shell is more than three feet long, and its body forms a meal for a hundred persons. It is found in the Indian seas and in different parts of the Pacific ocean.

Many of the animals of this kind are furnished with an organ denominated their foot, consisting of a fleshy mass attached to their body, whose motions are produced like those of the tongue of quadrupeds. This foot often gives rise to a number of filaments or threads, by which the animal is capable of attaching itself to rocks or other marine substances; thus, as it were, being moored or anchored, and secured from the influence of the waves. The two valves of their shell are held together by strong muscles which pass from one to the other; and when these are relaxed, the shells open mechanically, by means of an elastic substance placed in the hinge of the joint which connects them.

There are several other orders of the Mollusca, but the characteristics by which they are distinguished, are too obscure or minute to be here described.

SECTION IX.

Class VIII. Vermes or Worms.

The term Vermes or Worms has been used with great vagueness in natural history, and employed to designate animals to which the name was not appropriate. It is now, however, more restricted in its application, and is made to include only a small class of animals, which have some circumstances in common with each of the three classes last described, but still not exactly resembling any. They are sometimes called, by way of distinction, *Worms with red blood*, as they are the only invertebral animals which have red blood; and sometimes *Annelides*, from the structure of their body, which is of a cylindrical, elongated shape, divided into a great number of rings.

Their nervous system resembles that of the Insects and Crustacea. Their organs of sense consist merely in some fleshy tentacula, which surround the mouth and answer the purpose of feeling and touching. In some species, certain black points appear around the head, which have been supposed to be eyes, but this is doubtful. Their blood is nearly of the colour of that of the vertebral animals, but not of so bright and deep a red. It circulates in a double system of vessels, but there is no distinct, fleshy heart to give it motion. They breathe by means of branchiæ, which are sometimes within and sometimes without their bodies. They have no limbs, but on each of the rings, of which their bodies are composed, are little bristly projections which answer in some sort the purpose of feet. Their mouths are sometimes armed with jaws, and sometimes consist in a mere tube or sucker.

Their bodies are soft and compressible. All, except the earthworm, inhabit the water. Many of them bury themselves in the sand; others form themselves a sort of tube or habitation of sand, bits of dirt, gravel, or other materials; and others exude from their surfaces a calcareous matter, which produces a shell around them.

Among the animals belonging to this class are the earthworm, the leech, and the hairworm.

The appearance of Earthworms is familiar to all. They attain sometimes to the length of a foot, and have as many as an hundred and twenty rings, each of which is furnished with the little bristles or spines above mentioned. They emit through certain pores a slimy fluid, which lubricates their bodies and thus gives them an easier passage through the earth, which they traverse in every direction. They feed upon roots, woody fibres, and the remains of animal and vegetable matter. They swallow earth also in considerable quantity, but this is probably on account of the animal or vegetable matter in a state of decomposition, which it may contain. When cut through the middle, each portion becomes a distinct individual. And in some worms nearly resembling the earthworm, but residing in the water, the power of reproduction is nearly equal to that of the polypes.

The Leech has three jaws or rather lancets, with which it pierces the skin of animals, in order to suck their blood. Its tail is furnished with a shallow cup or disk, by which it is able to fix itself firmly to different objects, while obtaining its nourishment in this manner; and by means of the same organ, it moves from place to place. There are several species of the leech, of which the medicinal leech (Hirudo medicinalis) is the most valuable, from the use made of it in local blood-letting. The horseleech (Hirudo sanguisuga) has the same power of drawing blood, but the wounds which it makes are sometimes poisoned, and followed by bad effects.

The body of the Gordius or Hair-worm, is long, shaped like a thread or hair, nearly smooth and round. It is a vulgar notion that the hair of the human head or of a horse's tail, if thrown into the water, acquires life and is converted into a worm. A species of the hair-worm, in Africa and the Indies is extremely noxious. It is of a pale, yellowish colour, and is frequently met with among the grass, especially when covered with dew. It often insinuates itself into the naked feet or limbs of children and unwary persons, where it produces an inflammation that is sometimes fatal. Great care and attention are required in extracting it; for if it be broken during the operation, the part which remains in the flesh, continues alive and is quite as troublesome as the whole.

SECTION X.

Class IX. Zoophytes.

The class of Zoophytes is the last division of the animal kingdom, and the lowest in the scale of the animated creation. It includes an immense number of individuals but obscurely and imperfectly known, and which have but few points of resemblance and connexion with one another. In general they have no nervous system, no complete vascular circulation, no distinct apparatus for respiration, and no sense but that of feeling and perhaps that of tasting. This is not true, however, without exception ; for in some instances, traces of a nervous system, of a circulation, and of respiratory organs, may be detected, as is particularly the case in the Echinodermata, the first order of Zoophytes. They are covered with a well organized skin, and often with a sort of shell with points or spines. They have an internal cavity in which are lodged several distinct intestines, and vessels which maintain an imperfect circulation. There are also distinct organs for respiration, and many filaments which probably perform imperfectly the functions of a nervous system. To this order belong the sea-urchin, the common star-fish, the sea-egg, &c. They are the most perfect of Zoophytes in their structure, and are endowed with a curious set of organs for the purpose of motion. Their shells are pierced with a large number of holes, regularly arranged, through which project the feet of the animal, or rather the instruments answering the purpose of feet. These are little hollow cylinders composed of a membranous substance, and ending in a kind of knob, which is also hollow. They are filled with a liquid, which is furnished to them by reservoirs situated within the body. The animal at will can either lengthen these cylinders and distend their extremities by forcing this liquid into them, or exhaust it, and thus shorten and contract them. When it is exhausted, the knob or disk is drawn into a cuplike form, and thus may be firmly fixed to whatever object it is applied, like a cupping glass ; and when the liquid is again thrown into it, it is again loosened. By this arrangement, which enables it to fix and loosen, and at the same time to lengthen and shorten these organs of motion, the animal is enabled to move itself from place to place. Some of the animals of this order are composed of several branches united together in one common centre like the spokes of a wheel, and hence they are called starfish, or more commonly fivefingers. Their mouth is in the centre where the several branches meet. Others are globular, and others oblong, like the sea-urchin and sea-egg.

The Intestinal Worms belong also to the class of Zoophytes. Those which inhabit the bowels of children are well known. But there is scarce any animal which is not infested by one or more kinds of them. They can exist only within the bodies of the animals to which they belong, and it is seldom that the same species infests more than one kind of animal. They have no visible organs of respiration or circulation, and those of digestion are very imperfect and indistinct. They are not confined to the intestines, but are found in other canals and passages of the body, and even in the substance of parts, as in the liver, brain, and eye. The difficulty of accounting for their existence in these parts, has given rise to the opinion of some naturalists, that they are spontaneously engendered; but it is known with regard to many of them, that they produce eggs, and a living offspring; and it is contrary to all the analogy of nature to ascribe, in these obscure cases, to chance and the spontaneous operations of matter, the production of effects, which, in all other instances, are the result of a perfect and wonderful adaptation of organs to the end in view.

The Sea-nettles, or Sea-anemones, are still less perfect. Their bodies are circular, and in their centre is the mouth which leads to several rude and imperfect cavities in the substance of the animal, answering the purposes of stomach and intestines. They are generally found attached by their base to some rock or marine substance; but this attachment is voluntary, for they can at will disengage themselves. Generally, however, they perform no other motion than that of opening and closing their mouths, and extending the tentacula with which they are surrounded. With these they grasp animals coming within their reach, such as small fish, mollusca, worms, &c. These they swallow, and after having digested their flesh, throw out their bones, shells, and other refuse matter by the same opening, which is their only one.

The Medusæ do not differ much from these, except that they are merely of a gelatinous, slimy consistence, and are never found fixed by their base. They are common, and are often seen in immense shoals. One species of them is vulgarly known by the name of sunfish.

The Polypes have a hollow, cylindrical, or conical body, with one extremity open which serves for their mouth, and is surrounded by a number of tentacula. The simple cavity thus formed, constitutes their only organ, and performs all the functions of which they are capable. They seize their prey and convey it to their mouths with the tentacula, and, as their bodies are gelatinous and semitransparent, the operation of digestion may be seen going on within. Many of the polypes have been celebrated on account of the fact, that when one is divided into several pieces, each piece becomes a distinct animal, perfect in all its parts. The immense beds of coral and the different kinds of sponge, are nothing but the habitations of infinite numbers of these little animals, and are produced by their labour.

The Animalcules are animals still more minute, and are scarcely discernible except by the assistance of the microscope. Thousands of them are in this way brought to our view, of various shapes, sizes, and appearances. Most of them offer to the view merely a gelatinous mass, capable of an imperfect sort of motion. Some, however, present appearances of a structure, which might give them a claim to a higher rank in the scale of beings, did not their minuteness prevent a proper examination. These animals are principally found in some animal and vegetable fluids and infusions, and hence have sometimes received the name of Infusoria.

This completes a view of the whole animal kingdom, beginning with man, the most perfect member of it, and descending to those obscure and minute creatures which are scarcely visible except with the assistance of the microscope. It will be observed that one common plan pervades the whole; that the same general objects are had in view, in the structure of every class, and that there is a general analogy in the methods employed for effecting these objects, although there is a great variety in the details; and that there is a grand simplicity in the design, though a great diversity in the means. In short, not only in the structure of each individual animal, but in the wonderful manner in which that structure is varied to correspond to the nature, habits, and wants of the different classes, we may perceive the wisdom, the power, and the benevolence of that great Creator, who has devised and formed, and who continues to uphold the myriads of animated beings with which the earth is filled.

Philosophy

OF

NATURAL HISTORY.

CHAPTER I.

OF RESPIRATION.

"By the air is meant that common elastic fluid which envelops the whole earth, and extends to a certain distance from its surface. It constitutes what is called the atmosphere. By its weight, its compressibility, and its pressure in all directions, it insinuates itself into every vacuity; and its presence is absolutely necessary to the existence of every vegetable and animal. In order, however, to understand the manner in which it contributes to the support of living things, it is necessary to give some account of its composition.

"Although the air, as we breathe it, seems to be a simple and homogeneous fluid, yet it is in fact composed of two distinct constituent or elementary parts, upon the mixture or combination of which, its adaptation to the preservation of life depends; containing, besides, some other ingredients of minor importance. These main elements are two permanently elastic fluids or gases, called oxygen, and nitrogen or azote. Atmospheric air contains about twenty-three parts, by weight, of the former, and seventy-seven of the latter, out of one hundred; or, since oxygen is the heaviest of the two gases, twenty-one, by measure, of oxygen, and seventy-nine of azote. It is upon the oxygen of the air, that its fitness for supporting animal life depends; for, when an animal is confined in a small quantity of air till this is exhausted, it dies from suffocation, although the azote remains unaltered.

"No animal can exist in an active state without air, but different classes of animals differ very much as to the manner in which the function of respiration is performed. The influence which the air exerts, is always upon the circulating fluid or blood. It produces some change in it, or imparts some principle to it, which renders it fit to be distributed to the body for its nourishment. In all the animals, which have red blood, viz. the Mammalia, Birds, Reptiles, and Fishes, this change consists, so far as can be observed, in imparting to the dark red or venous blood, which is sent to the lungs by the heart, a bright red or vermilion colour. In this state, it is returned to the heart, and thence distributed throughout the body by the arteries.

"In the Mammalia, the air is alternately drawn into the lungs and expelled from them, by the action of the diaphragm and muscles of the ribs. This is called the inspiration and expiration of the air, and is constantly going on in order to produce the requisite change upon the blood, which is continually passing through the lungs. In the greater part of the animals of this class, if this process be stopped but for a few moments, death is the inevitable consequence; but in some species it may be suspended for a longer period. This is the case with the seal and the whale. Even men may acquire by habit the power of existing a considerable time without breathing, as is the case with the fishermen who dive for pearls;* but many of the stories which have been related with regard to this subject, are probably destitute of foundation.

"There are many other kinds of air or gas, which may be taken into the lungs, beside the atmospheric; but no other, which will support life. Even pure oxygen itself, and some gases which contain oxygen, although they will support life longer than any other kinds of air, will yet finally prove fatal. It is only when oxygen is combined with azote in the proportion above mentioned, that it is adequate to the continual support of life.† The quantity of air ordinarily contained in

* "The pearl-fishers have been said to remain half an hour or more under water. The accounts, however, which state so extraordinary a fact as this, must be looked upon with some doubt. It seems impossible, from what we know on the subject, that any human being could exist and remain capable of *action* under water, more than a few minutes.

† "Water destroys the life of animals merely by preventing the admission of air; it does not itself enter the lungs, or at most only a very small quantity. There are some gases which operate in the same way. The windpipe

the lungs of a common-sized man, immediately after an inspiration, has been calculated to be about two hundred and eighty cubic inches, and about forty inches are drawn in and thrown out at each inspiration and expiration; so that the whole mass of air is not changed at every breath, but a large proportion remains constantly present, and distends the lungs.

'If the air which has been respired be examined, a change will be found to have taken place in its composition. A part of its oxygen has disappeared, and in its place is found about the same bulk of carbonic acid or fixed air. There is also a considerable quantity of watery vapour. This change is undoubtedly connected with the effect produced upon the colour of the blood in respiration; and many have endeavoured to give some account of the mode in which it takes place. But it is a process which we shall probably never be able fully to understand. A similar change is produced upon the air respired by all animals of whatever class.

'Respiration has been supposed to be the cause of animal heat. Various opinions have been advanced to account for the manner in which it maintains the temperature of our bodies. None of them, however, seems perfectly satisfactory. It appears undoubtedly to have some very close connexion with respiration, and dependance upon it; for the degree of heat in animals is generally proportioned to the vigour and quantity of respiration. The temperature of birds is higher than that of man, and they consume a greater quantity of air. Reptiles and fishes have cold blood, and the amount of respiration in them is comparatively small. The same remark is true of all cold-blooded animals. But we are not yet acquainted with the exact nature of the connexion between respiration and animal heat.*

is spasmodically closed against them, and they do not enter the lungs; such are carbonic acid gas, ammoniacal gas, chlorine or oxymuriatic gas, &c. when unmixed. Other gases are inspired with sufficient ease, but produce death either merely for the want of oxygen, as hydrogen and pure azote; or, in a certain sense, by poisoning the blood or destroying its vital properties, as carburetted and sulphuretted hydrogen, and carbonic oxide. Oxygen alone, as has been remarked above, and nitrous oxide, which contains a greater proportion of it than atmospheric air, are capable of supporting life for a considerable period but finally prove fatal. The latter is celebrated for its intoxicating and exhilirating effects, when respired.

* 'Animal heat has been supposed to arise from a chemical action taking place in the lungs at the time of the change of venous blood into arterial, in the same way that heat is produced by many other chemical operations; but if this were true, the lungs ought to be hotter than any other part of the body, which is not the case. It has been also supposed to arise from a great-

'Respiration commences immediately after birth, and at the same time a change is produced in the course of the circulation. Before birth, only a very small proportion of the blood is carried through the lungs; but after birth and through life, the whole of it. The connexion between the action of the lungs and that of the heart, is very close and important. The functions they perform are mutually dependent, and neither can go on alone. If the circulation cease by the cessation of the action of the heart, respiration is immediately interrupted. If, on the other hand, respiration be impeded, the heart does not stop at once; but as the dark, venous blood is no longer changed in its properties, as usual, in the lungs, it is returned to the heart in the same state, and is then sent throughout the body; and being totally unfit for the purposes of life, destroys it, by cutting short the action of all the organs. The effect of its contact upon the brain, is an immediate *suspension* of life; and, if the cause be long continued, it is never restored. But in many cases of this kind, as in persons apparently drowned, circulation and respiration may be renewed, if they have not been too long interrupted, by blowing air into the lungs, and by the application of warmth and stimulating substances to the body.

"Beside these uses of the function of respiration, it is made subservient to a number of other important purposes. All animals furnished with lungs, express their wants, their affections and aversions, their pleasures and pains, either by words, or by sounds peculiar to each species. These are produced by different changes in the windpipe or canal through which the air is drawn into the lungs. The inferior animals are by this means enabled to maintain some sort of communication with others of the same species, and can, to a certain extent, convey information and express their affections and wants. But how far they are intelligible one to another, it is impossible to ascertain.' On man alone, nature has bestowed the faculty of speaking, or of expressing his various feelings and ideas, by a regular, extensive, and established combination of articulate sounds. To have extend-

er capacity for caloric in the arterial, than in the venous blood, in consequence of which, heat would be developed when the change from the former to the latter takes place in the capillary vessels of the body. This is more probable, but still hardly satisfactory. Neither of these hypotheses accounts for the independent temperature of eggs, which resist cold so long as they retain their life; nor for the power in men of resisting very high degrees of heat, with hardly any increase of the temperature of their bodies.

ed this faculty to the brute creation, would not, it is probable, have been of any use to them ; for, though some animals can be taught to articulate, yet none of them seem to have any idea of the proper meaning of the words they utter. Speech is performed by a very various and complicated machinery. In speaking, the tongue, the lips, the jaws, the whole palate, the nose, the throat, together with the muscles, bones, &c. of which these organs are composed, are all employed. This combination of organs we are taught to use when so young, that we are hardly conscious of the laborious task, and far less of the manner by which we pronounce different letters and words. The mode of pronouncing letters and words, however, may be learned by attentively observing the different organs employed by the speaker. By this means we are enabled to correct the various defects of speech, and even to teach the dumb to speak; for dumbness is seldom the effect of imperfection in the organs of speech, but generally arises from a want of hearing; and it is impossible for deaf men to imitate sounds which they never heard, except they be taught to use their organs by vision and by touching.

When about to laugh, we make a very full inspiration, which is succeeded by frequent, interrupted, and sonorous expirations. When the titillation is great, whether it arises from the mind or body, these convulsive expirations sometimes interrupt the breathing to such a degree as to endanger suffocation. Moderate laughing, on the contrary, produces health ; by agitating the whole body, it quickens the circulation of the blood, gives an inexpressible cheerfulness to the countenance, and banishes every kind of anxiety from the mind.

In weeping, we employ nearly the same organs as in laughing. It commences with a deep inspiration, which is succeeded by short, broken, sonorous, and disagreeable expirations. The countenance has a dismal aspect, and tears are poured out. Weeping originates from grief, or other painful sensations either of body or mind. When full vent is given to tears, grief is greatly alleviated. Both laughing and weeping have been reckoned peculiar to man. But this notion seems not to be well founded. Though the other animals express not their pleasures or pains in the same manner as we do, yet all of them exhibit their pleasant or painful feelings by symptoms or cries, which are perfectly understood by the individuals of each species, and, in many instances, by man. A dog, when hurt, complains in the bitterest terms; and, when he is afraid or perhaps melancholy, he expresses the situation of his mind by the most deplorable howlings. A bird, when sick, ceases to sing, droops the wing, abstains from food, assumes a lurid aspect, utters melancholy, weak cries, and exhibits every mark of depressed spirits. By this means, animals intimate the assistance they require, or soften those who maltreat them. Their plaintive cries are sometimes so affecting as to disarm their enemies, or to procure the aid of their equals. On the other hand, when animals are pleased or caressed, they discover, by their countenance, by their voice, by their movements, unequivocal symptoms of cheerfulness and alacrity of mind. Thus the expression of pleasure and pain by brute animals, though not uttered in the precise manner with those of the human species, are perfectly analogous, and answer the same intentions of nature.

By respiration and the instruments employed in the performance of it, the young of animals are enabled to extract milk from the breasts of the mother. By respiration, odours are conveyed to the nose; and coughing, sneezing, yawning, sighing, singing, and many other functions of the animal economy, are at least partly accomplished.

'The Respiration of Birds is carried on by an arrangement of the lungs, very different from that of the Mammalia. They are enabled to transmit air to almost every part of their bodies, by means of membranous sacks or bags, which receive it from the lungs through certain orifices or passages on the surface of these organs. The lungs themselves are firmly attached to the ribs, and are almost incapable of dilatation or contraction, but the air passes through them into the sacks by the action of the abdominal muscles. In this way it is diffused not only throughout the thorax and abdomen, but extends even to the cavities of many of the bones, which are distinguished from the others by their lightness, their white colour, and the absence of any bloody matter or marrow in their cavities.

'This provision answers probably several important purposes. It renders birds lighter in proportion to their bulk, than animals whose bones are filled with marrow or other solid substances, and thus gives them some advantage in flight; and generally in birds of the longest and highest flight, as eagles, this extension or diffusion of air is carried farther than in others. But a more important object of it probably is, to contribute to the muscular strength of these animals, by producing a very extensive operation upon the blood. The motions of birds in flight, require a much greater expenditure of power, than those of walking or running in other animals. This power depends upon the circulation of the red, arterial blood in the muscles which exert it, and in order to increase the proportion of this in the system, the influence of the air is carried over the whole system, instead of being confined to the lungs alone. It has been found that birds consume, in proportion to their size, more air than quadrupeds; and this arises from its extensive influence upon the blood. Thus, two sparrows were found by Lavoisier to require as much for their existence as a Guineapig, an animal many times as large. Another use ascribed to this arrangement by Mr Hunter, is that of acting in some degree, as a reservoir of air, to prevent the necessity of frequent respiration, which may be supposed inconvenient to birds while moving rapidly on the wing.

'The voice of birds is more remarkable and beautiful than that of any other animal except man; and on account of the large quantity of air which they have at command, it is very much more powerful. But the sounds uttered by man and quadrupeds are produced by the assistance of the mouth, at the top of the windpipe; whilst in birds the organ of voice is situated at the spot where it divides into two parts to go to the lungs on each side, that is to say, at the bottom of the throat. The variations of note are produced by a little membrane in the tube of the windpipe, which is made to vibrate by the air; and by means of a number of little muscles which either tighten or relax it, it is made to give the various notes. Hence, in singing, birds seldom close or make any motions with their beaks. That the voice is produced at this place, has been proved by cutting off the neck of some birds, which still retained the power of uttering their notes. The other parts of the windpipe are not, however, without their use. Some changes of tone are produced by shortening or lengthening it, and others by contracting or enlarging its upper opening into the mouth. The instrument of voice, in fact, resembles in many respects a musical instrument, and the excellence and beauty of the notes of birds, depend very much upon imitation and education. The nightingale if secluded in a cage when young, never sings so perfectly as in the wild state; unless exposed in a place, where it can hear the song of those which are at liberty. Many birds are capable of imitating a great variety of sounds, and some have been taught to sing very accurately tunes of human composition, merely by playing them upon some instrument in their hearing.

'The lungs of Reptiles do not consist, like those of the Mammalia and Birds, of a solid organ penetrated in every direction by the air tubes, but of a number of bags of a membranous texture, into which the air is conveyed In some, this is effected by the motion of the ribs and muscles of the abdomen, as in serpents and lizards. In others, as in frogs and tortoises, the air is swallowed. Respiration in these animals is not performed so regularly and constantly as in the higher classes. Only a comparatively small proportion of the blood is subjected to the influence of the air, at once; and they can subsist for a very considerable time without breathing, though its suspension at length destroys them. Tortoises have been known to live more than a month with their jaws tied closely together, and their nostrils filled with sealing wax. A toad lived for five days in a jar containing about a hundred cubic inches of air. In forty inches, another toad lived for twenty four hours, and a frog for fifty nine. This is many times longer than a warm-blooded animal could exist under the same circumstances.

'The temperature of the bodies of Reptiles is generally that of the air and water in which they are found. Still they have the power of resisting, during life, both very high and very low temperatures; and as their heat is seldom, under any circumstances, raised to a degree near to that of our bodies, they are designated as cold-blooded animals. This circumstance proceeds, probably, in some way from the limited quantity of their respiration; and with the same cause is connected their slow and feeble motions, their tendency to the dormant state, and in general their low degree of vital power.

'The Respiration of Fishes is carried on by means of gills or branchiæ, to which the air is applied through the medium of the water. Every portion of water contains a certain quantity of air combined or mixed in some way with it, and by this means is made capable of supporting respiration. A current of water is constantly passed over the gills by the action of the mouth, and produces the requisite change upon the blood circulating through them. This change is of the same kind with that taking place in the warm-blooded animals. It arises from the influence of the oxygen in the atmospheric air; and if the water be examined, after fishes have respired it, the air it contains will be found to have undergone a similar change of composition with that breathed by quadrupeds and birds.'

When a free communication with the external air is prevented by ice, or by artifice, fishes immediately discover symptoms of uneasiness, and soon perish. Ælian informs us, that, in winter, when the river Ister was frozen, the fishers dug holes in the ice; that great numbers of fishes resorted to these holes; and that their eagerness was so great, that they allowed themselves to be seized by the hands of the fishermen. Rondeletius made many experiments on this subject. If, says he, fishes are put into a narrow-mouthed vessel filled with water, and a communication with the air be preserved, the animals live, and swim about, not for days and months only, but for several years. If the mouth of the vessel, however, be closely shut, either with the hand, or any other covering, that the passage of the air is excluded, the fishes suddenly die. Immediately after the mouth of the vessel is closed, the creatures rush tumultuously, one above another, to the top, contending which of them shall soonest receive the benefit of the air. In the shallow parts of rivers, when frozen, many fishes are found dead. But, when parts of a river are deep or rapid, the fishes fly from the ice, and by this means avoid destruction.

These, and similar experiments, have been repeated by Mr Willoughby, and many other modern authors; and they have uniformly been attended with the same event. A carp, in a large vessel full of water, was placed in the receiver of an air-pump. In proportion as the air was exhausted by working the pump, the surface of the animal's body was covered with a number of bubbles. The carp soon breathed quicker, and with more difficulty. A little after, it rose to the surface in quest of air. The bubbles on its surface next disappeared; the belly, which before was greatly swollen, suddenly collapsed; and the animal sunk to the bottom, and expired in convulsions.

'Air is distributed in the bodies of Insects by a great number of tubes or canals called *tracheæ*, which convey it to every part. These communicate with the external air by means of openings called *stigmata*, which furnish a constant supply. That these organs are destined for the transmission of air, has been proved by repeated experiments; for when stopped up by the application of oil, or other unctuous substances, the animals soon lose their existence. In some insects they protrude externally to some distance from the body, and have the appearance of one, two, or three tails; and in others they arise from the back and sides.'

In contemplating the parts of animals, when the uses of these parts are not apparent, we are apt to deceive ourselves by rashly supposing them to answer purposes for which they were never intended by nature. Impressed with this idea, M. de Reaumur was not satisfied with the notion of Godart and others, that the long tails of certain worms were intended to keep them steady in their motions, and prevent them from rolling. Reaumur observed, that these worms or grubs could lengthen or shorten their tails at pleasure, but that they were always longer than the animal's body. Because these tails have some resemblance to that of a rat, he distinguishes the animals by the name of *rat-tailed worms*. These worms are aquatic, and never appear on dry ground till they are about to undergo their first transformation. Reaumur, in order to observe their economy more closely, collected a number of rat-tailed worms, and put them into a glass vessel filled two inches high with water. At first they were considerably agitated, each seemingly searching for a proper place of repose. Some of them swam across, others attached themselves to the sides, and others rested at the bottom of the vessel. In a quarter of an hour they were almost entirely tranquil, and Reaumur soon discovered the real use of their long tails. Upon examining the vessel, he found that each of the animals, in whatever situation they were placed, extended its tail exactly to the surface; that, like other aquatic insects, the respiration of air was necessary to their existence; and that the tail, which is tubular, and open at the extremity, was the organ by which this operation was performed. In this experiment, the distance from the bottom to the surface was two inches and, of course, the tails were of equal length. To discover how far the animals could extend their tails, he gradually augmented the height of the water, and the tails uniformly rose to the surface, till it was between five and six inches high. When the water was raised higher, the animals immediately quitted their station at the bottom, and either mounted higher in the water, or fixed upon the sides of the vessel, in situations which rendered it convenient for them to reach the surface with the points of their tails. These tails consist of two tubes, both of which are capable of extension and contraction. The first tube is always visible; but the second, which is the proper organ of respiration, is exserted only when the water is raised to a certain height. Through this tube the air is conveyed into two large tracheæ or windpipes within the body of the animal, and maintains the principle of life. When the tails are below the surface, they occasionally emit small bubbles of air, which are visible to the naked eye; and immediately are extended to the surface for fresh supplies. These worms pass the first and longest part of their lives under water; when near the time of their transformation, they leave the water, go under the ground, and are there transformed into chrysalids; and, lastly, from this state they are transformed into flies, and spend the remainder of their existence in the air.

Another species of aquatic worms merit attention. They frequent marshes, ditches, and stagnating waters. Their general colour is a greenish brown. Their bodies consist of eleven rings; and their skin is not crustaceous, but rather resembles parchment. Though these animals, before their transformation into flies, live in water, air is necessary to support their principle of life; and the apparatus with which Nature has furnished them for that important purpose deserves our notice. The last ring or termination of their bodies, is open, and serves as a conductor of air. From this last ring proceeds a number of hairs, which, when examined by the microscope, are found to be real feathers with regular vanes. In particular situations, they bend the last ring in such a manner as to reach the surface of the water or mud in which they are placed. These feathers prevent the water from entering into the tube, or organ of respiration; and, when the animal raises the termination of its body to the surface, in order to receive air, it erects and spreads the feathers, and by this means exposes the end of the tube to the atmosphere. When cautiously cut open, two large vessels, or tracheæ, appear on each side, and occupy almost one half of the body. Both of these windpipes terminate in the open tube, or last ring. Though these worms are furnished with organs of respiration, and actually respire air, yet M. de Reaumur discovered that some of them could live more than twenty-four hours without respiration.

So anxious is Nature to provide animals, in every state of

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their existence, with air, that, after the transformation of many insects into chrysalids, she creates instruments for that purpose, which did not exist previous to their transformation. The rat-tailed worms, formerly mentioned, soon after they are transformed into chrysalids, instead of a soft, pliable skin, are covered with a hard, crustaceous substance, seemingly impervious to the air; and the tail, which was the windpipe of the animal in its first state, gradually vanishes. In a few hours, however, four hollow horns shoot out, two from the fore, and two from the hind part of what was the head of the animal. These horns, which are hard and tubular, are discovered to be real windpipes, destined for the introduction of air into the chrysalis, a state in which the animals have the appearance of being almost totally dead, and, of course, would seem to have little use for respiration. It is likewise discovered that these horns, which pierced the hard exterior covering, terminate in as many tracheæ in the body of the animal. This fact affords a strong example of the necessity of air for sustaining the principle of life, even in its lowest condition. After these animals pass from the chrysalis state to that of flies, they are deprived both of their tails and horns. But Nature, in this last stage of their existence, has not left them without proper resources for the introduction of air into their bodies. Instead of protuberant tracheæ in the form of tails or horns, they now, like other flies, receive air by means of stigmata, or holes, variously disposed over different parts of the body.

The nymphs of the libella, or dragon-fly, respire water by an aperture at the termination of their bodies. These nymphs sometimes throw out the water, at certain intervals, with such force, that the stream is perceptible at the distance of two or three inches from their bodies. When kept some time out of the water, the desire or necessity of respiration is augmented; and, accordingly, when replaced in it, inspirations and expirations are repeated with unusual force and frequency. If you hold one of these nymphs in your hand, and apply drops of water to the posterior end of its body, it instantly, by an apparatus similar to the piston of a pump, sucks it in, and the dimensions of its body are visibly augmented. This water is again quickly thrown out by the same instrument. But, though this insect respires water, air seems to be not the less necessary to its existence; for, like other insects, the whole interior part of its body is amply provided with large and convoluted tracheæ; and, externally, there are several stigmata destined for the introduction of air.

The worms, or nymphs, of the ephemeron flies merit attention. They have received the denomination of *ephemeron*, because very few of them survive the day in which they are transformed into flies. Many of them live not one hour after their transformation. When in the worm and nymph states, they generally live in holes near the surface of the water; and under these two forms, continue to grow till they are mature for passing into the last and shortest period of their existence. Swammerdam informs us, that some of them remain three years under water, others two, and others one only.

On each side of their bodies, there are six or seven protuberances, which have the appearance of so many oars. With these instruments the animals describe arches in the water, first on one side, and then on the other, with astonishing rapidity. This circumstance led Clutius, and some other authors, to think that these protuberances were fins or instruments of motion, and that the animals were fishes. But Reaumur remarked that they moved these fins with the same rapidity when the animals were at rest, as when they were in motion; and that, instead of fins, when examined by the microscope, he discovered them to be gills through which the creatures respire. Each gill consists of a short trunk, and two large branches or tubes, which give off on all sides a number of smaller ramifications, and are perfectly similar to the tracheæ of other insects. At the origin of every gill, two tracheæ penetrate the trunk, and are dispersed through the body of the animal.

'The Crustacea, the Mollusca, and Worms, all respire by means of gills, which, although they differ in some measure from those of fishes, are formed upon the same plan. In a few instances they respire air by itself, but in general through the medium of water alone. In some animals of these classes the gills are situated upon the outside of their bodies, but commonly within. Zoophytes have no distinct organs for respiration; yet the air seems, in some way or other, absolutely necessary for their existence also, and probably penetrates their bodies, and acts upon their blood, by means entirely unknown. These animals are all cold-blooded.

'This chapter will be concluded by a few miscellaneous remarks, relating to the respiration of different animals and appearances connected with it.'

Land-snails, at the approach of winter, bury themselves in the earth, or retire into holes of rocks, or of old buildings, where they remain in a torpid state during the severity of the season. For protection and warmth, these animals, when they go into their winter habitations, form, by means of a slime that issues from every pore of their bodies, a membranous cover, which stops up the mouths of their shells. But this pellicle or cover, though apparently pretty hard and solid, is so thin and porous as not entirely to exclude the entrance of air, without which the principle of life could not be continued. Accordingly, when by accident the pellicle is made too thick, and prevents a communication with the external air, the animal, to remedy the evil, makes a small aperture in its cover. In this state snails remain six or seven months, without food or motion, till the genial warmth of the spring breaks their slumber, and calls forth their active powers. Hence it would appear, that air is more immediately necessary to the preservation of animal life than food itself; for, in numberless instances, animals can live, not for days or weeks, but for months, without supplies of nourishment. None of them, however, are capable of existing nearly so long without having some communication with the air.

With regard to snails that live in fresh waters, or in the ocean, the species of which are numerous, their manner of respiring is singular. All of them have an aperture on the right side of the neck, through which they respire. They are frequently observed to straiten the orifice of this aperture, to stretch it out in the form of an oblong tube; and, in this state, they rise to the surface, in order to expel the former air, and take in a new supply.

But, though air seems to be an indispensable principle of animal life, yet many animals can live longer without the use of this element, or at least with smaller quantities of it, than others. Those animals which lie torpid during the winter, as the hedge-hog, the dormouse, the marmot, &c. though perhaps not entirely deprived of all communication with the air, exist, with only an occasional and interrupted respiration, till the heat of the spring restores their wonted powers of life, when a full respiration becomes again equally necessary as before their torpor commenced. The toad, like all the frog kind, is torpid in winter. At the approach of winter, it retires to the hollow root of a tree, to the cleft of a rock, and sometimes to the bottom of a ditch, or pond, where it remains for months in a state of seeming insensibility. In this last situation it can have very little communication with the air.

But still the principle of life is continued, and the animal revives in the spring. What is more wonderful, toads have been found, in a hundred places on the globe, inclosed in the heart of solid rocks, and in the bodies of trees, where they must probably have existed for centuries, without any apparent access either to nourishment or to air; and yet they were alive and vigorous.

These facts are supported by authorities so numerous and so respectable, that it is unnecessary to quote them. Many abortive attempts have been made to account for an animal's growing and living very long in the situations above described, without the possibility of receiving nourishment or air; especially as, like all other animals, when put into an exhausted receiver, it is soon destroyed. No satisfactory explanation, however, has ever been offered; and solitary exceptions like these do not invalidate the general principle, that the respiration of air, in a greater or less degree, is constantly necessary to the existence of every living thing.

'The presence of air is as necessary to the life of Plants, as to that of animals. They have a respiration carried on by means of their leaves, which consumes in the same way the oxygen of the atmosphere, and exhales, instead of it, carbonic acid.'

When placed in an exhausted receiver, the air contained in every part of their substance is soon extracted; and, in proportion as this air is likewise pumped out by the machine, the flowers and leaves show evident symptoms of debility; they become flaccid, pendulous, and assume a sickly appearance; and, if retained in that situation a certain length of time, their vegetating powers are irrecoverably extinguished.

Upon the whole, as the air we continually breathe is liable to be impregnated with exhalations from every substance to which it has access, the great importance of attention to its purity, is an obvious reflection. In building towns or houses, the situation, with regard to air, is a capital object. The vicinity of marshes, of stagnating waters, of manufactures of tallow, oil, sal-ammoniac, the smelting or corroding of metals of every kind, and many other operations which contaminate the air, should be either avoided or removed, as they are the pests of our senses, and the poisoners of our constitutions. Even in northern climates, houses surrounded with trees, or in the neighbourhood of luxuriant vegetables, are always damp, and infested with insects; and hence the ambient air is replete with the seeds of disease. Precautions of this kind are still more necessary in hot climates. Air absorbs a greater or less proportion of the particles of bodies, according to its degree of heat. In Madrid, however, in Constantinople, and in many other cities of warm regions, the houses are crowded together, the streets are narrow, and covered with filth of every kind. We cannot, therefore, be surprised, that human beings existing in such situations should be so frequently infected with pestilential diseases.

CHAPTER II.

OF THE MOTIONS OF ANIMALS.

'The motions performed by animals are of two kinds, voluntary and involuntary. The first are performed at the will of the animal, are under the direction of its intelligence and judgment, and are suggested by its desires, wants, passions, and affections. Such are the movements of its limbs, and organs of sense and voice, by which it moves about from place to place, and maintains a communication with its fellow-beings. The second, or involuntary motions, are placed totally out of the control of its will. It has no influence over their performance, and is not even conscious that they are performed. Of this kind are the motions of the heart, the stomach, &c.

'The voluntary motions are performed by the instrumentality of bones, articulations, muscles, and tendons. The bones are connected together by the articulations or joints, which are so constituted as to admit of the moving of one upon the other, like a hinge, as in the knee; or like a ball and socket, as in the hip and shoulder. The muscles are fleshy bodies of various lengths and sizes, formed of fibres, and terminated by tendons. These last are white and very strong cords, usually called sinews, by which the muscles are attached to the bones. The muscles have the power of shortening or contracting themselves; and in consequence of a diminution of their length, the bones to which they are fixed are moved upon their articulations in different directions, according to the situation of the muscle. And by the combined operations of a great many muscles, all the various motions of the bodies of animals are performed. Thus in mastication, the under jaw is, by the contraction of one set of muscles, drawn upwards with great force, so that the lower teeth are made to crush and grind the food against the upper; this contraction continues but for a moment, the muscles are relaxed, and by another set of them, the jaw is drawn downward. This motion is repeated as long as we continue eating. This motion is more simple than that of most of our limbs, but they are all performed upon the same general principle of muscular action.'

'The muscles compose a great part of the bodies of most animals. They constitute the greater part of the meat which is served up to us as food. In quadrupeds and some parts of birds, this is red; in fishes and most of the lower orders of animals, it is white. It may be distinguished from other parts by its fibrous or stringy texture, which is more or less distinct according to the size, strength, and moving powers of the animal to which it belongs, and in some is scarcely to be observed at all. The contraction of muscles and the consequent motions of the different organs,' depend upon some unknown influence derived to them from the brain and nerves. Hence the brain and nerves are the sources of every motion, as well as of every sensation. With regard to the causes which determine the actions of animals, these must be referred to sensation, and the consequent exertions of intellect. The first impression an object makes upon our senses stimulates us either to approach or retire from it, according as it excites affection or aversion. But man, and many other animals, have the power of resisting these original motives to action, and of remaining at rest, without either retiring or approaching. "If a man," says the Count de Buffon, "were deprived of sight, he would make no movement to gratify his eyes. The same thing would happen, if he were deprived of any of the other senses; and, if deprived of every sense, he would remain perpetually at rest, and no object would excite him to move, though, by natural conformation, he were fully capable of motion." Natural wants, as that of taking nourishment, necessarily excite desire or appetite. But, if a man be deprived of sensation, want cannot exist, because all its sources are annihilated. An animal without some sensation is no animal, but a dead mass of matter.

Sensation is the only stimulus to animal motion; the aptness of the parts produces the effect, which varies according to the structure and destination of these parts. The sense of want creates desire. Whenever an animal perceives an object fitted to supply its wants, desire is the necessary consequence, and action or motion instantly succeeds.

'With regard to motions of the second kind, or involuntary motions, they are also performed by organs that commonly possess muscular fibres, but they are not connected with bones. The heart is a hollow muscle, which contracts in every direction upon the blood, and consequently throws it with great force into the arteries. The stomach is also a hollow muscle, which acts upon its contents by contraction; and the same is true of most of the internal organs where motion is produced. By motions of this kind, the most important functions of the system are performed; as the circulation of the blood; the digestion of food; the peristaltic motion of the intestines; the absorption of the chyle; its transmission from the abdomen into the subclavian vein, &c. Yet none of these operations has any dependence upon our will or inclinations.' Together with the action of the lungs in respiration, they have received the denomination of *vital* and *involuntary motions*, because most of them go on without any conscious exertions of the intellectual principle. If such a variety of nice and complicated movements had been left to the determination and direction of our minds, they must necessarily have occupied too much of our attention; and many of them would infallibly have been neglected during sleep, when consciousness often is almost totally suspended. But Nature in her operations is always wise. She has given to man, and other animals, the direction of no movements but what are easily performed, contribute to pleasure and health, and enable them to acquire food corresponding to the structure of their bodies and the elements in which they live.

It would be foreign to the design of this work, and ill suited to those to whom chiefly it is intended to be useful, to enter into the *rationale* of animal motion; to mention the number, insertion, and direction of the muscles employed in moving the different parts of animated bodies; or to account for the modes by which animals walk, leap, fly, swim, creep, &c. Such discussions would not only require a volume, but a thorough acquaintance with all the depths of anatomical and mathematical knowledge. What follows, therefore, will consist of some desultory observations; and the subject will be concluded by enumerating a few examples of movements peculiar to certain animals.

'Every class of animals has in general its limited sphere of motion, from which the individuals belonging to it seldom depart. Thus quadrupeds are constructed so as to move with the greatest facility upon the earth, birds in the air, and fishes in the water; yet there are exceptions with regard to all these classes. The bat is furnished with wings, and can traverse the air with as much facility as many birds; the ostrich, though furnished with wings, is confined to the earth, and can only walk or run; whilst the flying-fish has fins so large, that it is capable of raising itself out of the water, and maintaining a flight for some time in the air.

'The limbs of animals are always adapted to the particular kind of motions which their mode of life requires. Thus in monkeys and apes, which subsist principally upon the fruit of trees, and in fact make them for the most part their place of residence, in order to avoid the destruction to which they are constantly exposed from beasts of prey, the limbs are particularly adapted for climbing. Upon plain ground they seem to go with ease neither upon four legs nor two. In the kanguroos, the hind legs are so long in proportion to those before, that they are scarce able to go on all fours, but move from place to place principally by means of immense leaps, which the great strength of their hind legs enables them to make with facility. In the woodpecker, parrot, &c. whose food obliges them to climb along the trunks and branches of trees in search of it, the toes are particularly adapted for climbing; and in the waders who go into very deep water in quest of their prey, the legs are of very great length and nearly destitute of feathers. Examples of this kind might be multiplied to a great extent.'

The motions of animals are proportioned to their weight and structure. A flea can leap some hundred times its own length. Were an elephant, a camel, or a horse, to leap in the same proportion, their weight would crush them to atoms. The same remark is applicable to spiders, worms, and other insects. The softness of their texture, and the comparative smallness of their specific gravity, enable them to fall with impunity from heights that would prove fatal to larger and heavier animals.

The different movements to which animals are stimulated by the desire of food, by the appetite for frolic and exercise, by their hostilities, and by other exciting causes, give animation and vivacity to the whole scene of nature. A silent and motionless prospect, however beautiful and variegated, soon ceases to please, and at last becomes insupportable. Motion, says Mr Harris, is the object or cause of all sensation. In music we hear it; in savours we taste it; in odours we smell it; in touch we feel it; in light we see it.

Animals, furnished with destructive weapons, or endowed with uncommon strength, courage, or ingenuity, are proportionally slower in their movements than the weaker kinds. The same remark is applicable to those species whose food is always at hand. Worms, caterpillars, and many other insects, in order to procure nourishment, are under no necessity of taking an extensive range. But the motions of birds and fishes are extremely rapid; because, in quest of food, they are obliged to pass through large tracts, and they have also many enemies to avoid.

Timid animals, as the hare, the rabbit, the guineapig, &c. are almost perpetually in motion. Even when perfectly undisturbed, they are restless, and betray a continual anxiety of danger. They run about, stop short, erect their ears, and listen. The guineapig frequently raises itself on its hind legs, and snuffs all around to catch the scent of food when hungry, or to increase its circle of hearing when afraid.

The movements of many animals are so extremely slow, that some of them, particularly those of the shell tribes, are generally supposed to be destitute of the power of moving. It is a common notion, that both the fresh and salt water muscles have not the locomotive faculty. But this is a vulgar error. It is almost unnecessary to mention, that the exterior part of muscles consists of two shells hinged together, which the animals can open or shut at pleasure. Every person must likewise have observed, in the structure of the animal itself, a fleshy protuberance of a much redder colour, and denser consistence, than the other parts of the body. This muscular protuberance which consists of two lobes, has been denominated a *trunk* or *tongue:* but it is an instrument by which the creature is enabled to perform a progressive, though a very slow motion; and, therefore, in describing its manner of moving, I shall call these two lobes the animal's *tentacula* or *feet.*

When inclined to remove from its present situation, the river muscle opens its shell, thrusts out its tentacula, and, while lying on its side in a horizontal position, digs a small furrow in the sand. Into this furrow, by the operation of the same tentacula, the animal makes the shell fall, and thus brings it into a vertical position. We have now got our muscle on end ; but how is he to proceed ? He stretches forward his tentacula, by which he throws back the sand, lengthens the furrow, and this fulcrum enables him to proceed on his journey.

With regard to marine muscles, their progressive motion is performed in the same manner, and by the same instruments. When not in motion, they are firmly attached to rocks or small stones, by many threads of about two inches in length, which serve the purpose of a cable. Without this provision of nature, these animals must become the sport of the waves, and the species would soon be annihilated. But how does the creature spin these threads ? A cylindrical canal extends from the origin to the extremity of the tentacula. In this canal, an extremely glutinous substance is secreted, which the animal, by the operation of certain muscles, has the power of forcing out, and of attaching, in the form of strong threads, to stones or other solid bodies. More than a hundred and fifty of these cables are often employed in mooring a single muscle. The substance of the threads is exceedingly viscous, indigestible in the human stomach, and is probably the cause of those fatal consequences which sometimes happen to inattentive eaters. In Scotland, these threads are called the *beards* of muscles, and should be carefully pulled off before the animals are thrown into the stomach.

Other bivalved shellfish, the species of which are numerous perform a progressive or retrograde motion, by an instrument that has no small resemblance to a leg and foot. But the animals can, at pleasure, make this leg assume almost every kind of form, according as their exigencies may require. By this leg they are not only enabled to creep, to sink into the mud, or disengage themselves from it, but to perform a motion, which no man could suppose shellfish were capable of performing. When the tellina, or limpin, is about to make a spring, it puts the shell on the point or summit, as if with a view to diminish friction. It then stretches out the leg as far as possible, makes it embrace a portion of the shell, and by a sudden movement similar to that of a spring let loose, it strikes the earth with its leg, and actually leaps to a considerable distance.

The spout-fish has a bivalved shell, which resembles the handle of a razor. This animal is incapable of progressive motion on the surface; but it digs a hole or cell in the sand, sometimes two feet in depth, in which it can ascend and descend at pleasure. The instrument or leg by which it performs all its movements is situated at the centre. This leg is fleshy, cylindrical, and pretty long. When necessary, the animal can make the termination of the leg assume the form of a ball. The spout-fish, when lying on the surface of the sand, and about to sink into it, extends its leg from the inferior end of the shell, and makes the extremity of it take on the form of a shovel, sharp on each side, and terminating in a point. With this instrument the animal cuts a hole in the sand. After the hole is made, it advances the leg still farther into the sand, makes it assume the form of a hook, and with this hook, as a fulcrum, it obliges the shell to descend into the hole. In this manner the animal operates till the shell totally disappears. When it chooses to regain the surface, it puts the termination of the leg into the shape of a ball, and makes an effort to extend the whole leg; but the ball prevents any farther descent, and the muscular effort necessarily pushes the shell upward till it reaches the surface or top of the hole. It is amazing with what dexterity and quickness these seemingly awkward motions are performed.

It is remarkable that the spout-fish, though it lives in salt water, abhors salt. When a little salt is thrown into the hole, the animal instantly quits its habitation. But it is still more remarkable, that, if you seize the animal with your hand, and afterwards allow it to retire into its cell, you may strew as much salt upon it as you please, but the fish will never again make its appearance. If you do not handle the animal, by applying salt, you may make it come to the surface as often as you incline; and fishermen often make use of this stratagem. This behaviour indicates more sentiment and recollection than one would naturally expect for a spout-fish.

The scallop, another well known bivalved shellfish, has the power of progressive motion upon land, and likewise of swimming on the surface of the water. When this animal happens to be deserted by the tide, it opens its shell to the full extent, then shuts it with a sudden jerk, by which it often rises five or six inches from the ground. In this manner it tumbles forward till it regains the water. When the sea is calm, troops, or little fleets of scallops are often observed swimming on the surface. They raise one valve of their shell above the surface, which becomes a kind of sail, while the other remains under the water, and answers the purpose of an anchor, by steadying the animal, and preventing its being overset. When an enemy approaches, they instantly shut their shells, plunge to the bottom, and the whole fleet disappears. By what means they are enabled to regain the surface, we are still ignorant.

Like many other bivalved shellfish, the oyster has the power of squirting out water with a considerable force. By thus suddenly and forcibly ejecting a quantity of water, the animal repulses such enemies as endeavour to insinuate into its shell while open. By the same operation, if not firmly attached to rocks, to stones, or to one another, the oyster retreats backwards, or starts to a side in a lateral direction. Any person may amuse himself with the squirting and motions of oysters, by putting them in a plate situated in a horizontal position, and which contains as much sea-water as is sufficient to cover them. The oyster has been represented by many authors, as an animal destitute not only of motion, but of every species of sensation. The Abbé Dicquemare, however, has shown, that it can perform movements perfectly corresponding to its wants, to the dangers it apprehends, and to the enemies by which it is attacked. Instead of being destitute of all sensation, oysters are capable of deriving knowledge from experience. When removed from situations which are constantly covered with the sea, devoid of experience, they open their shells, lose their water, and die in a few days. But even when taken from similar situations, and laid down in places from which the sea occasionally retires, they feel the effects of the sun's rays, or of the cold air, or perhaps apprehend the attacks of enemies, and accordingly learn to keep their shells close till the tide returns. Conduct of this kind plainly indicates both sensation and a degree of intelligence.

The progressive motion of the sea-urchin, or sea-egg, a well known multivalved shellfish, merits our attention. This animal, of which there are several species, is round, oval, or shaped like a bias-bowl. The surface of the shell is divided into beautiful triangular compartments, and covered with numberless prickles; from which last circumstance it has received the appellation of *sea-urchin*, or *sea-hedge-hog*. These triangles are separated by regular belts, and perforated by a great number of holes. Each hole gives lodgment to a fleshy horn* similar to those of the snail, and susceptible of the same movements. Like the snail, the sea-urchin uses its horns when in motion; but their principal use is to fix the animal to rocks, stones, or the bottom of the ocean. By means of the horns and prickles, which proceed from almost ever point of the shell, the sea-urchin is enabled to walk either on its back or on its belly. The limbs it most generally employs are those which surround the mouth. But, when it chooses, it can move forward by turning on itself like the wheel of a coach. Thus the sea-urchin furnishes an example of an animal employing many thousand limbs in its various movements. The reader may try to conceive the number of muscles, of fibres, and of other apparatus, which are requisite to the progressive motion of this little animal.

The motion of that species of medusa, or sea-nettle, which attaches itself to rocks, and to the larger shellfish, is extremely slow. The sea-nettles assume such a variety of figures, that it is impossible to describe them under any determinate shape. In general, their bodies have a resemblance to a truncated cone. The base of the cone is applied to the rock or other substance to which they adhere. With regard to colour, some of them are red, some greenish, some whitish, and others are brown. When the mouth, which is very large, is expanded, its margin is surrounded with a great number of fleshy filaments, or horns, similar to those of the snail. These horns are disposed in three rows around the mouth, and give the animal the appearance of a flower. Through each of these horns the sea-nettle squirts water, like so many jets-d'eau. What is peculiar in the structure of these creatures, the whole interior part of their body, or cone, is one cavity, or stomach. When searching for food, they extend their filaments, and entangle any small animals they encounter. When they meet with their prey, they instantly swallow it, and shut their mouths close like a purse. Though the animal should not exceed an inch or an inch and a half in diameter, as it is all mouth and stomach it swallows large whelks and muscles. These shell-animals sometimes remain many days in the stomach before they are ejected. Their nutritious parts are at last, however, extracted; but how does the sea-nettle get quit of the shell? The creature has no other aperture in its body but the mouth, and this mouth is the instrument by which it both receives

* See Introduction, p. 84.

nourishment, and discharges the excrement, or unprofitable part of its food. When the shell is not too large, the sea-nettle has the power of turning its inside out, and by this strange manœuvre the shell is thrown out of the body, and the animal resumes its former state. But, when the shell presents itself in a wrong position, the animal cannot discharge it in the usual manner; but, what is extremely singular, near the base of the cone, the body of the creature splits, as if a large wound had been made with a knife, and through this gash the shell of the muscle, or other shell, is ejected.

With regard to the progressive motion of the sea-nettle, it is as slow as the hour-hand of a clock. The whole external part of its body is furnished with numerous muscles. These muscles are tubular, and filled with a fluid, which makes them project in the form of prickles. By the instrumentality of these muscles, the animal is enabled to perform the very slow motion just now mentioned. But this is not the only means by which the sea-nettle is capable of moving. When it pleases, it can loosen the base of the cone by which it is attached to the rock, reverse its body, and employ the filaments round its mouth as so many limbs. Still, however, its movements are very slow.

CHAPTER III.

OF INSTINCT.

'Animals exhibit, in many cases, an appearance of skill, forethought, sagacity, and judgment, which seems to indicate a high degree of the reasoning faculty, or else an intuitive or instinctive knowledge which directs them in their actions. Philosophers have been at a loss to determine, whether in these instances the sagacity of brutes is to be attributed to a power of judging and reasoning similar to that of man, or to a mere instinct. Some have contended that all the actions of animals, of whatever kind, are founded upon experience, observation, and reasoning; whilst others maintain that they are produced by an innate and original principle, which directs and governs the animal without any voluntary exercise of judgment on its own part.

'The probability is, that the truth lies between these two opinions. Some of the operations performed by the higher orders of animals, can only be accounted for upon the supposition, that they are possessed of the same intellectual powers with mankind, though to a much less extent; whilst, on the other hand, many of them can only be the result of a blind and undiscriminating instinct. The wonderful instances of sagacity, memory, and other intellectual operations exhibited by dogs, elephants, horses, &c. some of which will be related in the course of this work, can only be the result of the former; whilst the prudence and anticipation of remote consequences so often exhibited by animals, particularly those of the class of insects, can only proceed from the latter.

'But with all their powers of mind, such as they are, and all their curious and astonishing instincts, there is an immense distance between man and other animals, with respect to the capacity for improvement. The latter are not capable of making progressive advancement from one generation to another, and cannot transmit nor communicate the results of their experience for the benefit of others. Hence, although in some rare instances, brutes exhibit a sagacity and shrewdness which seem to equal that which a man would evince in similar circumstances, yet they do not impart the same qualities to others or to their offspring. Man, who owes more to reason, owes less to instinct than any other animal; though he is not entirely destitute of it. His knowledge is, for the most part, the result of his own experience and observation, or of that of others which has been communicated to him, and his actions are guided by the knowledge thus acquired. The infant is consequently more helpless and imbecile than the young of other animals, and is long in acquiring the same comparative degree of dexterity and cunning.

'In animals possessed of both intellect and instinct in a considerable degree, they modify and assist the operation of each other, and often give to these animals the appearance of much higher exertions of thought than they can really lay claim to. Thus the instinct of the beaver in building his habitation, is in some measure guided and modified by his experience and observation. He accomodates their structure to the peculiar situation of the place he has fixed upon, and the circumstances of the surrounding country, and this has induced some to believe that the whole process on the part of this animal belongs to the understanding. But it is more probable that instinct is the main guide, whilst reason aids and modifies its operation. The want of this aiding and modifying influence of the rational principle, is shown in many remarkable instances among the lower orders of animals, which possess it only to a small extent. Thus the instinct of the honey-bees prompts them to preserve their queen on all occasions from injury or from escape; but, under some circumstances, it leads them to measures for effecting this purpose, which are so violent as to destroy her. The instinct of the flesh-fly induces it to deposit its eggs in putrid meat, but deceived by the smell of a particular plant, which exactly resembles that of carrion, they hover around it and deposit them on its leaves, where they can never come to perfection. Experience and observation, had these insects been capable of them, would have directed them to avoid these destructive consequences.

'The difference between an animal governed almost wholly by instinct, and one principally under the direction of reason, can be in no way more strikingly illustrated, than by comparing the habitations of man with those of lower animals. The dwellings of man differ in all ages and countries. In his savage state, they are less perfect than the nests of birds, the huts of the beaver, or the cells of bees; in the cultivated stages of society, they are, it is unnecessary to say, almost infinitely more perfect. His are always varying, while theirs are always the same, and improve by experience and observation only in some points of secondary importance. They do not invent; they only modify the suggestions of instinct, from absolute necessity. The first society of bees constructed their cells as perfectly as is now done; they have never improved; but the first man had no shelter but such as the foliage of a tree could afford him.

'In considering the facts which are known with regard to instinct, they may be arranged under two heads; the first exhibiting examples of pure instinct; and the second, of such instincts as can accommodate themselves to peculiar circumstances and situations, or such as are improvable by experience and observation.'

1. *Of pure Instincts.*

By *pure* instincts are meant those, which, independent of all instruction and experience, instantaneously produce certain actions when particular objects are presented to animals, or when they are influenced by peculiar feelings. Of this class the following are examples.

In the human species, the instinct of sucking is exerted immediately after birth. This instinct is not excited by any smell peculiar to the mother, to milk, or to any other substance; for infants suck indiscriminately every thing brought into contact with their mouths. The desire of sucking, therefore, is innate, and coeval with the appetite for air.

When caterpillars are shaken off a tree in every direction, all of them instantly turn toward the trunk, and climb up, though they have never formerly been on the surface of the ground.

Young birds open their mouths upon hearing any kind of noise, as well as that of their mother's voice. They have no apprehensions of harm; neither do they offer to use their wings till they acquire more strength and experience. The lion's cub is not ferocious till he feels force and activity for destruction.

Insects invariably deposit their eggs in situations most favourable for hatching and affording nourishment to their future progeny. Butterflies, and other insects, whose offspring feed upon vegetables, uniformly fix their eggs upon such plants as are most agreeable to the palate and constitution of their young. Water insects never deposit their eggs on dry ground. Butterflies which have been transformed in the house, exhibit marks of the greatest uneasiness because they cannot find a proper nidus for their eggs; and, when every other resource fails, they paste the eggs on the panes of the window.

Some species of animals look not to future wants. Others, as the bee and the beaver, are endowed with an instinct which has the appearance of foresight. They construct magazines, and fill them with provisions.

The common bees attend the female, or queen, do her many little services, and even feed her with honey from their trunks. When deprived of the female, all their labours cease, till a new one is obtained, whom they treat with much respect, and renew their usual operations. They make cells of three different dimensions, for holding workers, drones, and females; and the queen-bee, in depositing her eggs, distinguishes the three different kinds, and never puts a royal or a drone egg into the cells destined for the reception of the working bees. What is equally singular, the number of these cells is proportioned to that of the different bees to be produced. One royal cell weighs as much as one hundred of the common kind. When there are several females in a hive, the bees work little till they have destroyed all the females but one. If more than a single female were allowed to remain in a hive, a greater number of eggs would be laid than the working bees are able to make cells for receiving.

The wood-piercing bee, which is one of the solitary species, gnaws with amazing rapidity and perseverance, a large hole in old timber. After laying her eggs in the cells, she deposits such a quantity of glutinous matter as nourishes the worms produced from these eggs till the time of their transformation into flies. She then pastes up the mouth of the hole, and leaves her future offspring to the provision she has made for them.

The bees of that species which build cylindrical nests with rose leaves, exhibit a very peculiar instinct. They first dig a cylindrical hole in the earth. When that operation is finished, they go in quest of rose-bushes; and, after selecting leaves proper for their purpose, they cut oblong, curved, and even round pieces, exactly suited to form the different parts of the cylinder.

The solitary wasp digs holes in the sand. In each hole she deposits an egg. But how is the worm, after it is hatched, to be nourished? Here the instinct of the mother merits attention. Though she feeds not upon flesh herself, and certainly knows not that an animal is to proceed from the egg, and far less that this animal must be nourished with other animals, she collects ten or twelve small green worms, which she piles one above another, rolls them up in a circular form, and fixes them in the hole in such manner that they cannot move. When the wasp-worm is hatched, it is amply stored with the food nature has destined for its support. The green worms are devoured in succession; and the number deposited is exactly proportioned to the time necessary for the growth and transformation of the wasp-worm into a fly, when it issues from the hole, and is capable of procuring its own nourishment.

There are many other instances of ichneumon wasps and flies, which, though they feed not themselves upon worms, lay up provisions of these animals for the nourishment of their young; and each kind is adapted to the constitution of the worm that is to proceed from their eggs.

Birds of the same species, unless when restrained by peculiar circumstances, uniformly build their nests of the same materials, and in the same form and situation, though they inhabit very different climates. When removed by necessity from their eggs, they hasten back to them with anxiety. They turn and shift their eggs, which has the effect of heating them equally. Ducks and geese cover up their eggs till they return to the nest. A hen sits with equal ardour upon eggs of a different species, or even upon artificial eggs.

The spider, the dermestes, and many insects of the beetle kind, exhibit an instinct of a very uncommon nature. When put in terror by a touch of the finger, the spider runs off with great swiftness; but, if he finds that whatever direction he takes, he is opposed by another finger, he then seems to despair of being able to escape, contracts his limbs and body, lies perfectly motionless, and counterfeits every symptom of death. In this situation I have pierced spiders with pins, and torn them to pieces, without their discovering the smallest mark of pain. This simulation of death has been ascribed to a strong convulsion, or stupor, occasioned by terror. But this solution of the phenomenon is erroneous. I have repeatedly tried the experiment, and uniformly found, that, if the object of terror be removed, in a few seconds the animal runs off with great rapidity. Some beetles, when counterfeiting death, suffer themselves to be gradually roasted without moving a single joint.

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2. *Of instincts which can accommodate themselves to peculiar circumstances and situations, or such as are improvable by experience and observation.*

'Almost all the instincts of the higher kinds of animals, are included under this division. There are few of them which are not capable of being improved by education and experience, and this is particularly the case with those of man.'

The ostrich has been accused of unnaturalness, because she leaves her eggs to be hatched by the heat of the sun. In

Senegal, where the heat is great, she neglects her eggs during the day, but sits upon them in the night. At the Cape of Good Hope, however, where the degree of heat is less, the ostrich, like other birds, sits upon her eggs both day and night.

Rabbits dig holes in the ground for warmth and protection. But, after continuing long in a domestic state, that resource being unnecessary, they seldom employ this art.

Bees, when they have not room enough for their operations, augment the depth of their honey-cells. The female bee, when the cells are not sufficiently numerous to receive her eggs, lays two or three in each cell. But, a few days after, when the cells are increased, the working bees remove all the supernumerary eggs, and deposit them in the newly constructed cells.

When a wasp, in attempting to transport a dead companion from the nest, finds the load too heavy, he cuts off its head, and carries it out in two portions.

In countries infested with monkeys, many birds, which, in other climates, build in bushes and clefts of trees, suspend their nests upon slender twigs, and, by this ingenious device, elude the rapacity of their enemies.

The nymphs of water-moths, commonly called *cod-bait*, cover themselves, by means of gluten, with pieces of wood, straw, small shells, or gravel. It is necessary that they should always be nearly in equilibrium with the water in which they live. To accomplish this purpose, when their habitations are too heavy, they add a piece of wood; when too light, a bit of gravel.

A cat was known to frequent a closet, the door of which was fastened by a common iron latch. A window was situated near the door. When the door was shut, she gave herself no uneasiness. As soon as she was tired of her confinement, she mounted on the sole of the window, and with her paw dexterously lifted the latch and came out. This practice she continued for years.

'These are but a few examples of instinct; many others more curious and interesting will be found in the different chapters of this work, which treat of other subjects connected with the character and history of animals.'

The notion that animals are machines, is perhaps too absurd to merit refutation. Though no animal is endowed with mental powers equal to those of man, yet there is not a faculty of the human mind, but evident marks of its existence are to be found in particular animals. Senses, memory, imagination, the principle of imitation, curiosity, cunning, ingenuity, devotion, or respect for superiors, gratitude, are all discoverable in the brute creation. Neither is art denied to them. They build in various styles; they dig; they wage war; they extract peculiar substances from water, from plants, from the earth; they modulate their voices so as to communicate their wants, their sentiments, their pleasures and pains, their apprehensions of danger, and their prospects of future good. Every species has its own language. They ask and give assistance to each other. They speak of their necessities; and this branch of their language is more or less extended, in proportion to the number of their wants. Gestures and inarticulate sounds are the signs of their thoughts. It is necessary that the same sentiments should produce the same sounds and the same movements; and, consequently, each individual of a species must have the same organization. Birds and quadrupeds, accordingly, are incapable of holding discourse to each other, or commmunicating the ideas and feelings they possess in common. The language of gesture prepares for that of articulation; and some animals are capable of acquiring a knowledge of articulate sounds. They first judge of our thoughts by our gestures; and afterwards acquire the habit of connecting these thoughts with the language in which we express them. It is in this manner that the elephant and the dog learn to obey the commands of their masters.

Infants are exactly in the same condition with brutes. They understand some of our gestures and words long before they can articulate. They discover their wants by gestures and inarticulate sounds, the meaning of which the nurse learns by experience. Different infants have different modes of expressing their wants. This is the reason why nurses know the intentions of infants, though they are perfectly unintelligible to strangers. When an infant, accordingly, is transferred from one nurse to another, the former instructs the latter in the gestures and inarticulate language of the child.

The idea of a *machine* implies a select combination of the common properties of matter. The regularity of its movements is a proof that they are totally distinct from animal or spontaneous motion. A machine has nothing analogous to sensation, which is the lowest characteristic of an animal. An *animated machine*, therefore, is an absurd abuse of terms. It confounds what nature has distinguished in the most unambiguous manner.

Brutes, like men, learn to see objects in their proper position, to judge of distances and heights, and of hurtful, pleasurable, or indifferent bodies. Without some portion of reason, therefore, they could never acquire the faculty of making a proper use of their senses. A dog, though pressed with hunger, will not seize a piece of meat in the presence of his master, unless it be given to him ; but, with his eyes, his movements, and his voice, he makes the most humble and expressive petition. If this balancing of motives be not reasoning, by what other name can it be called ?

Animals, recently after birth, know not how to avoid danger. Neither can they make a proper use of their members. But experience soon teaches them what is pleasant and what is painful, what objects are hurtful and what salutary. A young cat, or a dog, which has had no experience of leaping from a height, will, without hesitation, precipitate itself from the top of a high wall. But, after perceiving that certain heights are hurtful, and others inoffensive, the animal learns to make the distinction, and never afterwards can be prevailed upon to leap from a height which it knows will be productive of pain.

Young animals examine every object they meet with. In this investigation they employ all their organs. The first periods of their life are dedicated to study. When they run about, and make frolicksome gambols, it is Nature sporting with them for their instruction. In this manner they improve their faculties and organs, and acquire an intimate knowledge of the objects which surround them. Men who, from peculiar circumstances, have been prevented from mingling with companions, and engaging in the different amusements and exercises of youth, are always awkward in their movements, cannot use their organs with ease or dexterity, and often continue during life, ignorant of the most common objects.

CHAPTER IV.

OF THE SENSES.

No animal of which we have any knowledge is endowed with more than the five external senses of smelling, tasting, hearing, touch, and seeing; and no animal, however imperfect, is destitute of the whole. Without organs of sensation, in a smaller or greater number, animal or intellectual existence is to us an inconceivable idea.

Our observations on the different instruments of sensation will proceed in the following order, namely, of the senses of smelling, of tasting, of hearing, of touch, and of seeing. In general, it may be remarked, that all sensation is conveyed to the mind by an unknown influence of the nerves. If the optic, olfactory, or any nerve distributed over an organ of sensation, be cut, or rendered paralytic, the animal instantly loses that particular sense. This is a fact universally established by experiment. But that the nerves, which are nearly similar in every part of the body, should, when distributed over the eye, the ear, the tongue, the nose, convey to the mind feelings so different, is the most mysterious part of this subject.

Of Smelling.

In man, and many other animals, the organ by which the sense of smelling is conveyed to the mind, has received the general appellation of *nose* or *nostrils*. The more immediate instrument of this sensation is a soft, vascular, porous membrane, and is known by the name of the *pituitary membrane*, or *Schneiderian membrane*. This membrane is totally covered with infinite ramifications and convolutions of the olfactory nerves. These nerves are almost naked, and exposed to the action of the air which passes through the nose in performing the function of respiration. But Nature, ever attentive to the ease and convenience of her creatures, has furnished the nostrils with a number of glands, or small arteries, which secrete a thick, insipid mucus. By this mucus, the olfactory nerves are defended from the action of the air, and from the painful stimuli of acrid odours.

The odours perceived by smelling are extremely various. Some of them convey to us the most delightful and refreshing sensations, and others are painful, noxious, and disgusting. The effluvia of odoriferous bodies float in the atmosphere, and act upon the olfactory nerves of different animals, and sometimes of different individuals of the same species, in such a manner as to produce very different sensations. What is pleasant to the nostrils of one animal is highly offensive to those of another. Brute animals select their food chiefly by employing the sense of smelling, and it seldom deceives them. They easily distinguish noxious from salutary food; and they carefully avoid the one, and use the other for nourishment. The same thing happens with regard to the drink of animals. A cow, when it can be obtained, always repairs to the clearest and freshest stream; but a horse, from some instinctive impulse, uniformly raises the mud with his feet, and renders the water impure, before he drinks.

In the selection of food, men are greatly assisted, even in the most luxurious state of society, by the sense of smelling. By smelling we often reject food as noxious, and will not risk the other test of tasting. Victuals which have a putrid smell, as equally offensive to our nostrils as hurtful to our constitutions, we avoid with abhorrence; but we are allured to eat substances which have a grateful and savoury odour. The more frequent and more acute discernment of brutes in the exercise of this sense, is entirely owing to their freedom, and to their using natural productions alone. But men in society, by the arts of cookery, by the unnatural assemblage of twenty ingredients in one dish, blunt, corrupt, and deceive both their senses of smelling and tasting. Were we in the same natural condition as the brutes, our sense of smelling would enable us to distinguish, with equal certainty, noxious from salutary food. Brutes, as well as men, prefer particular foods to others. This may be considered as a species of luxury; but it should likewise be considered, that all the articles they use are either animal or vegetable substances in a natural state, neither converted into a thousand forms and qualities by the operation of fire and water, nor having their savour exalted by stimulating condiments. Domestic animals are nearly in the same condition with luxurious men. A pampered dog snuffs and rejects many kinds of food, which, in a natural state, he would devour with eagerness.

It is not unworthy of remark, that, in all animals, the organs of smelling and of tasting are uniformly situated very near each other. Here the intention of Nature is evident. The vicinity of these two senses forms a double guard in the selection of food. Were they placed in distant parts of the body, they could not so readily give mutual aid.

The air we breathe is perpetually impregnated with an infinity of different particles which stimulate the olfactory nerves, and give rise to the sensation of smell. When our senses are not vitiated by unnatural habits, they are not only faithful monitors of danger, but convey to us the most exquisite pleasures. Even the sense of smelling is always productive either of pleasure or pain. The fragrance of a rose, and of many other flowers, is not only pleasant, but gives a refreshing and delightful stimulus to the whole system, and may be considered as a species of wholesome nourishment; while the odours proceeding from hemlock, and from many other noxious vegetable, animal, and mineral substances, are highly offensive to our nostrils. Hence we are naturally compelled to embrace the one class of sensations and to avoid the other.

Some animals, as the dog, the fox, the raven, &c. are endowed with a most exquisite sense of smelling. A dog scents various kinds of game at considerable distances; and, if the fact were not confirmed by daily experience, it could hardly gain credit, that he can trace the odour of his master's foot through all the winding streets of a populous city. If we judge from our own feelings, this extreme sensibility in the nose of a dog is to us perfectly incomprehensible.

'In animals which do not breathe air, the odoriferous particles are conveyed to the organ of smelling through the medium of water. In fishes, the nostrils do not form a tube or canal, as in animals which breathe air, but consist of a simple cavity on each side of the nose, into which the water, impregnated with odours, flows, and communicates the sensation of smell.

'In the invertebral animals, no distinct organ for this sense has ever been discovered, and yet they almost all appear to possess it in no inconsiderable degree. Some insects, as was mentioned in the last chapter, are induced by the odour of certain fetid plants, to deposit their eggs upon the leaves, believing them to be putrid flesh; they must, therefore be possessed of the sense of smelling, for in no other way could they be deceived. A probable conjecture with regard to the organ by which it is exercised, is that which refers it to the air tubes or tracheæ, by which they respire. In the mollusca, it is not improbable that the whole surface of the skin, which resembles in its structure the pituitary membrane of other animals, is the seat of this sense; and the same may be true of worms and zoophytes.'

Of Tasting.

The tongue and palate are the great instruments of this sensation. With much wisdom and propriety, the organ of taste is situated in such a manner as enables it to be a guardian to the alimentary canal, and to assist the organ of smell in distinguishing salutary from noxious food. The tongue is perpetually moistened with saliva, a liquor which, though insipid itself, is one great cause of all tastes. The saliva of animals is a very powerful solvent. Every substance applied to the tongue is partially dissolved by the saliva before the sensation of taste is excited. When the tongue is rendered dry, or coated by disease, or any other cause, the sense of taste is either vitiated or totally annihilated.

'When we exercise this sense, the substance which we wish to taste is pressed by the tongue against the roof of the mouth, and the different parts of the mouth are contracted closely around the tongue and the sapid body. The more complete and perfect the contact which thus takes place, the more perfect is the act of tasting. The internal surface of the mouth is very little capable of perceiving or distinguishing tastes, unless this pressure takes place. In fact, if the mouth be held open and a substance of even a pretty powerful taste be applied to the tongue, the impression it gives is very indistinct and indefinite, and becomes perceptible only by closing the jaws and bringing the tongue up into contact with the roof of the mouth. Hence arises the pleasure we feel in the act of chewing and swallowing. The motion of the jaw, and the action of the teeth and tongue, mix the food with saliva, thus putting it into a fit state for producing the sensation of taste, and, at the same time, convey it between the tongue and the roof of the mouth; whilst, in swallowing, almost the whole internal surface of the mouth contracts upon and comes in contact with the morsel, raising the pleasure of taste to the highest degree.'

In some men the sense of taste is so blunt, that they cannot distinguish, with any degree of accuracy, the different species of that sensation. In others, whether from nature or from habit, this sense is so acute, that they can perceive the nicest distinctions in the savour of solids and of liquids.

Though the sense of taste varies in some individuals, yet, like figurative taste, the standard of agreeable and disagreeable, of pleasant and painful, is almost universally diffused over mankind and the brute creation. Every horse, and every ox, when in a natural state, eats or rejects the same species of food. But men in society, as well as domestic animals, are induced by habit, by necessity, or by imitation, to acquire a taste for many dishes, and combinations of substances, which, before the natural discriminating sense is perverted, would be rejected with disgust.

Some individuals of the human species have an aversion to particular kinds of food, which are generally agreeable. This aversion may be either original or acquired. I knew a child, who, from the moment he was weaned, could never be induced to take milk of any kind. These original aversions must be ascribed to some peculiar modification in the structure of the organ, or in the disposition of its nerves. But, in general, disgust at particular foods is produced by surfeits, which injure the stomach, and create, in that exquisitely irritable viscus, an insuperable antipathy to receive nourishment which formerly gave it so much uneasiness to digest.

Brute animals, especially those which feed upon herbage, and are not liable to be corrupted by example or necessity, distinguish tastes with wonderful accuracy. By the application of the tongue, they instantly perceive whether any plant is salutary or noxious. To enable them, amidst a thousand plants, to make this discrimination, their nervous papillæ, and their tongues, are proportionally much larger than those of man. 'This sense indeed seems particularly intended as a guard to the digestive organs, and subservient to them; and this more especially in other animals, than in man, who is accustomed to depend upon his judgment and experience, rather than his taste, in the selection of articles of food. Still that which is salutary for the stomach, is generally pleasant to the taste. It is probable that all animals possess the sense of taste, to enable them to make choice of and enjoy their food, and that, in all of them, the sense resides in those organs which are employed in receiving and swallowing it.'

Of Hearing.

The sensation of hearing is conveyed to the mind by undulations of air striking the ear, an organ of a very delicate and complex structure. In quadrupeds, the external ears are large, and provided with muscles by which they can erect and move them from side to side, in order to catch the undulations produced in the air by the vibrations of sonorous bodies, or to distinguish with greater accuracy the species of sound, and the nature and situation of the animal or object from which it proceeds. Though the human ears, like those of quadrupeds, are furnished with muscles, evidently intended for similar movements, yet, I know not for what reasons, there is not one man in a million who has the power of moving his ears. When we listen to a feeble sound, we are conscious of an exertion; but that exertion, and the motions produced by it, are confined to the internal parts of the organ.

The canals or passages to the internal parts of the ear are cylindrical, somewhat contorted, and become gradually smaller till they reach the membrane, which covers what is called the drum of the ear. This membrane, which is extremely sensible when acted upon by undulations of air, however excited, conveys, by means of a complex apparatus of bones, nerves, &c. the sensation of sound to the brain or sentient principle.

Infants hear bluntly, because the bones of their ears are soft and cartilaginous; and, of course, the tremulations excited in them by the motions of the air, are comparatively weak. Young children, accordingly, are extremely fond of noise. It rouses their attention, and conveys to them the agreeable sensation of sound; but feeble sounds are not perceived, which gives infants, like deaf persons, the appearance of inattention, or rather of stupidity.

'That air is the medium by which all sounds are propagated, has been established by repeated experiments. The sound of a bell suspended in the receiver of an air-pump, gradually diminishes as the air is exhausted, till it almost entirely ceases to be heard. On the other hand, when the quantity of air is increased by a condenser, the intensity of the sound is proportionally augmented. It has also been proved that sounds actually produced, cannot be transmitted through a vacuum, or a space deprived of air.

'The undulations of the air by which sounds are produced, have been illustrated by comparing them to the little circular waves or undulations which are produced when a stone is thrown into stagnant water. Similar motions are probably produced in the air by the vibrations of sonorous bodies. The celerity with which sounds, or undulations of air, move, has been computed. All sounds, whether acute or grave, strong or weak, move at the average rate of 1142 feet in a second of time. Hence, whenever lightning, or the fire of artillery is seen, its distance may be ascertained by determining the interval which elapses before the thunder, or the report is heard.*

'The force or intensity of sound is augmented by reflection from surrounding bodies. It is from this cause that the human voice, or any other noise, is always weaker and less distinctly heard in the open air, than in a house. A musket discharged upon a wide and extensive plain, sounds but little louder than the burning of a squib, whilst among buildings or hills, where there are a thousand reverberations, its report is very loud.'

The modifications of sound are not less various than those of tastes or odours. The ear is capable of distinguishing some hundred tones in sound, and probably as many degrees of strength in the same tones. By combining these, many thousand simple sounds, which differ either in tone or in strength, are perceived and distinguished by the ear. A violin, a flute, a French-horn, may each of them give the same tone; but the ear easily makes the distinction. The immense variety of sensations, arising from the organs of smelling, of tasting, and of hearing, enables animals to judge concerning the nature and situation of external objects. By habit we learn to know the bodies from which particular species of sounds proceed. Previous to all experience, we could not distinguish whether a sound came from the right or the left, from above or below, from a greater or a smaller distance, or whether it was the sound of a coach, of a drum, of a bell, or of an animal.

* 'It has been lately ascertained that the velocity of sound is considerably affected by different states of the atmosphere and of the weather, and by the wind. The lowest rate of its velocity is 1099, the highest 1164 feet per second.'

Hearing enables us to perceive all the agreeable sensations conveyed to our minds by the melody and harmony of sounds. This, to man at least, is a great source of pleasure and of innocent amusement. But some men are almost totally destitute of the faculty of distinguishing musical sounds, and of perceiving those delightful and diversified feelings excited by the various combinations of musical tones. Most men derive pleasure from particular species of music. But a musical ear, in a restricted sense, is by no means a general qualification. An ear for music, however, though not to be acquired by study, when the faculty itself is wanting, may be highly improved by habit and culture. Buffon, after examining a number of persons who had no ear for music, says, that every one of them heard worse in one ear than in the other; and ascribes their inability of distinguishing musical expression to that defect. But a musical ear seems to have no dependence on acuteness or bluntness of hearing, whether in one or in both ears. There are many examples of people who may be said to be half deaf, and yet are both fond of music and skilful practitioners. An ear for music, like a genius for painting or poetry, is a gift of Nature, and is born with the possessor.

Beside the innumerable pleasures we derive from music and agreeable sounds, the extension and improvement of *artificial* language must be considered as objects of the greatest importance to the human race. Without the sense of hearing, mankind would forever have remained mute. I mention *artificial*, or improved language, because, from a thousand observations which every person must have made, it is perfectly apparent, that, if destitute of a *natural* language, neither man nor the brute creation could possibly have existed and continued their species. As brutes, without information or experience, are capable of communicating to each other, by particular sounds and gestures, their pleasures and pains, their wants and desires, it would be the highest absurdity to suppose that the great Creator should have denied to man, the noblest animal that inhabits this globe, the same indispensable privilege. Without a basis there can be no fabric. Without a *natural*, no *artificial* language could possibly have existed. This point is clearly demonstrated, in a few words, by that most ingenious, candid, and profound philosopher, Dr Thomas Reid, formerly Professor of Moral Philosophy in the University of Glasgow. "If mankind," says Dr Reid, "had not a natural language, they could never have invented an artificial one by their reason and ingenuity. For all artificial language supposes some compact or agreement to affix a certain meaning to certain signs; therefore, there must be compacts or agreements before the use of artificial signs; but there can be no compact or agreement without signs, nor without language; and therefore there must be a natural language before any artificial language can be invented."*

Of Touch.

The sensations of smelling, tasting, hearing, and seeing, are conveyed to us by partial organs, which are all confined to the head. But the sense of touching, or of feeling, is not only common to these organs, but extends over almost every part of the body, whether external or internal. Though every sensation may be comprehended under the general appellation of *feeling*, yet what is called the sense of *touch* is properly restricted to the different sensations excited by bodies applied to the skin, and particularly to the tips of the fingers.

With regard to sensation in general, it is worthy of remark, that the eyes, the ears, the nostrils, the tongue, and palate, the palms of the hands, especially towards the points of the fingers, are more amply supplied with nerves than any other external parts of the body. The terminations of the nerves on the surface of the skin are soft and pulpy, and form minute protuberances resembling the nap of frieze-cloth, though greatly inferior in magnitude. These protuberances have received the denomination of *nervous papillæ*. They might be called *animal feelers;* for they are obviously the immediate instruments of sensation. If an object be presented to the eye, or any other organ of sensation, certain feelings are excited, which are either agreeable or disagreeable, according to the real or imaginary qualities which we consider as belonging to that object. The feelings thus excited instantly produce a change in the sensitive organs by which they are occasioned. If the object be possessed of disagreeable qualities, aversion is the necessary consequence. But, if beauty and utility are perceived in the object, pleasant emotions spring up in the

* Dr Reid's Inquiry into the Human Mind, on the Principles of Common Sense. S.

mind, which naturally induce a similar tone or disposition in the organs suited for the enjoyment of these qualities.

When examining or enjoying any object, it is natural to inquire, what are the changes produced in the nervous papillæ or organs of sensation? If an object possessed of agreeable feelings is perceived, the nervous papillæ instantly extend themselves, and, from a state of flaccidity, become comparatively rigid. This extension of the papillæ is not conjectural; it is founded on anatomical observation, and, in some cases, may be seen and felt by persons of acute and discerning sensations. When a man in the dark inclines to examine any substance, in order to discover its figure, or other qualities, he perceives a kind of rigidity at the tips of his fingers. If the fingers are kept long in this state, the rigidity of the nervous papillæ will give him a kind of pain or anxiety, which it is impossible to describe. The cause of this pain is an over-distension of the papillæ. If a small insect creeps on a man's hand, when the papillæ are flaccid, its movements are not perceived; but, if he happens to direct his eye to the animal, he immediately extends his papillæ, and feels distinctly all its motions. If a body be present, which, in the common state of the nerves, has scarcely any sensible odour, by extending the papillæ of the nostrils, an agreeable, disagreeable, or indifferent smell will be perceived. When two persons are whispering, and we wish to know what is said, we stretch the papillæ, and other organs of hearing, which are exceedingly complex. If a sound is too low for making an impression on the papillæ in their natural state of relaxation, we are apt to over-stretch the organ, which produces a painful or irksome feeling. When we examine a mite, or any very minute object, by the naked eye, a pain is propagated over every part of that organ. Several causes may concur in producing this pain, such as the dilating of the pupil, and the adjusting the crystalline lens; but the chief cause must be ascribed to the preternatural intumescence and extension of the papillæ of the retina, the substance of which is a mere congeries of nervous terminations. This circumstance confirms a former remark, that the immediate organs of sensation are more copiously supplied with nervous papillæ than those parts whose uses require not such exquisite sensibility; for a distinction in this respect is observable even among the sensitive organs themselves. They are furnished with nerves exactly proportioned to the subtility of the objects whose impressions they are fitted to receive. The eye possesses by far the greatest number. The particles of light are so minute, that, had not this wise provision been observed in the construction of the eye, it could never have been able to distinguish objects with such accuracy as at present it is capable of performing. When an insipid body, or a body which conveys but a feeble sensation of taste, is applied to the tongue, we are conscious of an effort which that organ makes in order to discover the quality of the body thus applied. This effort is nothing but the stretching of the nervous papillæ, that they may enlarge the field of contact with the body under examination.

The pleasure or pain produced by the sense of touch, depends chiefly on the friction, or number of impulses, made upon the papillæ. Embrace any agreeable body with your hand, and allow it to remain perfectly at rest, and you will find the pleasure not half so exquisite as when the hand is gently moved backward and forward upon the surface. Apply the hand to a piece of velvet, and it is merely agreeable; rub the hand repeatedly on the surface of the cloth, and the pleasant feeling will be augmented in proportion to the number of impulses on the papillæ. When a man is pinched with hunger, the sight or idea of palatable food raises the whole papillæ of his tongue and stomach. From this circumstance he is highly regaled by eating. But if he eats the same species of food when his stomach is less keen, the pleasure in the one case is not to be compared with what is felt in the other. The cause is obvious; his desire was not so urgent; the object, of course, was less alluring; and therefore he was more remiss in erecting his papillæ, or in putting them in a tone suited to such eminent gratification.

The same observations are applicable to disagreeable or painful objects of contact. If the hand is laid upon a gritty stone, or a piece of rusty iron, the feeling is disagreeable; but if it is frequently rubbed upon the surface of these bodies, the feeling becomes insufferably irksome.

It is by the sense of touch, that men and other animals are enabled to perceive and determine many qualities of external bodies. By this sense we acquire the ideas of hardness and softness, of roughness and smoothness, of heat and cold, of pressure and weight, of figure and of distance. The sense of touch is more uniform, and liable to fewer deceptions, than those of smelling, tasting, hearing, and seeing; because, in examining the qualities of objects, the bodies themselves must be brought into actual contact with the organ, without the intervention of any medium, the variations of which might mislead the judgment.

'The accuracy of this sense is much improved by habit; and in some cases where the senses of sight or hearing have been injured, this has acquired so great a degree of sensibility, as in a certain measure to supply their loss. Thus blind men are sometimes able to distinguish the qualities of objects with a wonderful degree of exactness, by means of the sense of touch; and the power they frequently possess of determining when they approach a wall, has been attributed in part to their perception of the effects produced upon the skin by the air, either on account of a change in the degree of its resistance or from some other alteration in it with which we are unacquainted.'

Of Seeing.

Of all the senses, that of seeing is unquestionably the noblest, the most refined, and the most extensive. The ear informs us of the existence of objects at comparatively small distances; and its information is often imperfect and fallacious. But the organ of sight, which is most admirably constructed, not only enables us to perceive thousands of objects at one glance, together with their various figures, colours, and apparent positions, but, even when unassisted, to form ideas of the sun and planets, and of many of the fixed stars; and thus connects us with bodies so remote, that imagination is lost when it attempts to form a conception of their immense magnitude and distances. This natural field of vision, however great, has been vastly extended by the invention of optical instruments. When aided by the telescope, the eye penetrates into regions of space, and perceives stars innumerable, which, without the assistance of art, would to us have no existence. Our ideas of the beauty, magnitude, and remoteness or vicinity of external objects, are chiefly derived from this delicate and acute instrument of sensation.

'The globe of the eye is contained within two coats, the *cornea* and the *sclerotica*. The cornea is that circular transparent membrane which covers a part of the anterior portion of the eye; and through whose central part is seen the pupil.

It gives a passage to the rays of light, and presents the appearance of a dark circle, when contrasted with the white of the eye. The remaining external covering of the organ is formed by the sclerotic coat. This, where it is visible, is of a bluish white colour, and is called the white of the eye. These two coats together form a globe or ball, within which are contained the immediate instruments of vision, consisting of the iris, the humours of the eye, and the retina. The iris is that coloured circle which surrounds the pupil within the cornea, and gives the peculiar colour to the eye. It is an extremely sensible membrane, placed as a sort of guard to the delicate organs within, to protect them from any sudden changes of light. When the light is strong, the fibres of the iris dilate towards the centre, and the pupil consequently becomes smaller, so that fewer rays are admitted. When the light is weak, the pupil becomes larger, and admits a larger number of rays.

'The humours of the eye are three in number, the aqueous, the crystalline, and the vitreous. The crystalline humour is a double convex lens, situated a little way behind the iris. The space which intervenes between this lens and the cornea is filled up by the aqueous humour. This is nearly of the consistence of water, and surrounds the iris entirely, permitting its light and delicate fibres to float freely in it. The vitreous humour occupies the remaining back part of the eye. It is contained in a great number of thin, membranaceous, and transparent cells, which, when punctured, pour out a fluid of the consistence of the white of an egg. The rays of light, in passing through the humours, are refracted, become concentrated, and produce an image upon the retina. This is a membrane formed by the optic nerve, which enters from the brain, is spread out on the inner surface of the back part of the eye, and receives the impressions made by the rays of light, after they have been concentrated by the humours. This impression is transmitted to the brain, and is the immediate cause of vision.'

By this curious apparatus, all the phenomena of vision are conveyed to the mind. But before we enter upon the manner in which the different parts of the eye concur in transmitting the rays of light and the images of objects to the retina, it will be necessary to give some general ideas concerning the nature of light, which is the universal medium of vision.

Light is supposed to consist of innumerable particles of matter, which proceed in direct lines from every part of luminous bodies, and constitute rays. The motion of light, though not instantaneous, is inconceivably swift. It has been discovered by philosophers, that rays of light coming from the sun reach this earth in eight minutes. Now the distance of the earth from the sun is so immense, that, supposing a cannon ball to move at the rate of five hundred feet in a second, it could not come from the sun to the earth in less than twenty-five years. At this rate, the velocity of light will be above ten million times greater than that of a cannon ball.

The rays of light, though they proceed in direct lines from luminous bodies, are refracted, or bent out of their course, in passing through different mediums, as the air, glass, and every transparent substance ; but, when they fall upon opaque bodies, they are reflected. Rays proceeding from any object and passing through a convex glass, or lens, are refracted and collected into a point, or small space, at a certain distance from the glass, which is called the *focus* of that lens.

The different humours of the eye, and the crystalline lens, are all denser than air or water ; of course, their power of refracting the rays of light is likewise greater. The rays proceeding from every point of an object, enter the pupil ; and the refraction of the different parts of the eye, which act as a lens, necessarily makes them cross each other in their passage to the retina. After crossing, they diverge till they are stopped by the retina, where they form an inverted picture. The upper part of the object is painted on the lower part of the retina, and the right side upon the left, &c. The celebrated Kepler first discovered, that distinct, but inverted, pictures of every object we behold are painted on the retina by the rays of light proceeding from visible objects. This discovery naturally led Kepler, as well as many other philosophers since his time, to inquire how we should see objects erect from inverted images on the retina.

Many ingenious theories have been invented, in order to explain this seemingly difficult question. To give even a cursory view of them would not only be tedious, but in a great measure useless. We shall therefore only remark, that their authors have uniformly assumed the principle, without proving it, that because the pictures are inverted on the retina, the mind ought also to perceive them in the same position. But this does by no means follow, and we can only resolve it into this, that animals see objects in their real position, although their images are inverted, by a law of nature. It is certain, that, unless distinct images are painted on the retina, objects cannot be clearly perceived. If, from too little light, remoteness, or any other cause, a picture is indistinctly painted on the retina, an obscure or indistinct idea of the object is conveyed to the mind. The picture on the retina, therefore, is so far the cause of vision, that, unless this picture be clear and well defined, our ideas of the figure, colour, and other qualities of any object presented to the eye, will be obscure and imperfect. The retina of the eye resembles a canvass on which objects are painted. The colours of these pictures are bright or obscure, in proportion to the distances of the objects represented. When objects are very remote, their pictures on the retina are so faint, that they are entirely obliterated by the vigorous and lively impressions of nearer objects, with which we are every way surrounded. On the other hand, when near objects emit a feeble light only, compared with that which proceeds from a remote object, as, for example, when we view luminous bodies in the night, then very distant objects make distinct pictures on the retina, and become perfectly visible. Hence a man, by placing himself in a dark situation, and looking through a long tube, without the intervention of a glass, may make a kind of telescope, which will have a considerable effect even during the day. For the same reason, a man at the bottom of a deep pit can see the stars at noon.

Another question with regard to vision has been much agitated by philosophers. Because a separate image of every object is painted on the retina of each eye, it was concluded, that we naturally see all objects double; that we learn to correct this error of vision by the sense of touching; and that if the sense of seeing were not constantly rectified by that of touching, we should be perpetually deceived as to the position, number, and situation of objects. The Count de Buffon mentions the real fact, though he ascribes it to a wrong cause. "When two images," says he, "fall on *corresponding* parts of the retinæ, or those parts which are always affected at the same time, objects appear single, because we are *accustomed* to judge of them in this manner. But when the images of objects fall upon parts of the retinæ which are not usually affected at the same time, they then appear double, because we have not acquired the *habit* of rectifying this unusual sensation. Mr Cheselden, in his anatomy, relates the case of a man who had been affected with a strabismus, or squinting, in consequence of a blow on the head. This man saw every object double for a long time: but he gradually learned to correct this error of vision, with regard to objects which were familiar to him; and, at last, he saw every object single as formerly, though the squinting was never removed. This is a proof still more direct, that we really see all objects double, and that it is by *habit* alone we learn to conceive them to be single."*

In this, and other passages, the Count de Buffon has pointed out the genuine cause (or ultimate fact) why we see objects single with two eyes. He tells us, that, though a distinct image is painted on each retina, whenever these images are painted on corresponding points of the retinæ, an object is perceived to be single. It is equally true, that, when one eye is distorted by the finger, or any other cause, in such a manner that the images are painted on points of the retinæ which do not correspond, the object is perceived to be double. Objects which are much nearer, or much more remote, than that to which both eyes are directed, appear double. If a candle is placed at the distance of ten feet, and a man holds his finger at arm's length between his eyes and the candle, when he looks at the candle, he sees his finger double, and when he looks at his finger, he sees the candle double. "In this phenomenon," Dr Reid properly remarks, "it is evident to those who understand optics, that the pictures of objects which are seen double, do not fall upon points of the retinæ which are similarly situated, but that the pictures of objects seen singly do fall upon points similarly situated. Whence we infer, that as the points of the two retinæ, which are similarly situated with regard to the centres, do correspond, so those which are dissimilarly situated do not correspond. It is to be observed, that although, in such cases as are mentioned in the last phenomenon, we have been accustomed from infancy to see objects double which we know to be single; yet custom and experience of the unity of the object never take away this appearance of duplicity."†

The sense of seeing, without the aid of experience, conveys no idea of distance. If not assisted by the sense of touching, all objects would seem to be in contact with the eye itself. Objects appear larger or smaller according as they approach or recede from the eye, or according to the angle

* Buffon, vol. 3, p. 7 Trans. S.
† Dr Reid's Inquiry, &c. p. 287. S.

they subtend. A fly, when very near the eye, seems to be larger than a horse or an ox at a distance. Children can have no idea of the relative magnitude of objects, because they have no notion of the different distances at which they are seen. It is only after measuring space by extending the hand, or by transporting their bodies from one place to another, that children acquire just ideas concerning the real distances and magnitudes of objects. Their ideas of magnitude result entirely from the angle formed by the extreme rays reflected from the superior and inferior parts of the object: hence every near object must appear to be large, and every distant one small. But after having, by touch, acquired ideas of distances, the judgment concerning magnitude begins to be rectified. If we judge solely by the eye, and have not acquired the habit of considering the same objects to be equally large, though seen at different distances, the nearest of two men, though of equal size, would seem to be many times larger than the farthest. But we know that the last man is equally large with the first; and, therefore, we judge him to be of the same dimensions. Any distance ceases to be familiar to us, when the interval is vertical, instead of being horizontal; because all the experiments by which we usually rectify the errors of vision, with regard to distances, are made horizontally. We have not the habit of judging concerning the magnitude of objects which are much elevated above or sunk below us. This is the reason that, when viewing men from the top of a tower, or when looking up to a globe or a cock on the top of a steeple, we think these objects much smaller than when seen at equal distances in a horizontal direction. During the night, on account of the darkness, we have no proper idea of distance, and, of course, judge of the magnitude of objects solely by the largeness of the angle or image formed in the eye, which necessarily produces a variety of deceptions. When travelling in the night, we are liable to mistake a bush that is near us for a tree at a distance, or a distant tree for a bush which is at hand. When benighted in a part of the country with which we are unacquainted, and, of course, unable to judge of the distance and figure of objects, we are every moment liable to all the deceptions of vision. This is the origin of that dread which some men feel in the dark, and of those ghosts and horrible figures which so many people positively assert they have seen in the night. Such figures are commonly said to exist in imagination only; but they often have a real existence in the eye; for, when we have no other mode of recognising unknown objects but by the angle they form in the eye, their magnitude is uniformly augmented in proportion to their vicinity. If an object, at the distance of twenty or thirty paces, appears to be only a few feet high, its height, when viewed within two or three feet of the eye, will seem to be many fathoms. Objects in this situation must excite terror and astonishment in the spectator, till he approaches and recognises them by actual feeling; for, the moment a man examines an object properly, the gigantic figure it assumed in the eye instantly vanishes, and its apparent magnitude is reduced to its real dimensions. But if, instead of approaching an object of this kind, the spectator flies from it, he retains the idea which the image of it formed in his eye, and he may affirm with truth, that he beheld an object terrible in its aspect, and enormous in its size. Hence the notion of spectres, and of horrible figures, is founded in nature, and depends not solely on imagination.

When we have no idea of the distance of objects by a previous knowledge of the space between them and the eye, we try to judge of their magnitudes by recognising their figures. But, when their figures are not distinguishable, we perceive those which are most brilliant in colour to be nearest and those that are most obscure to be at the greatest distance. From this mode of judging many deceptions originate. When a number of objects are placed in a right line, as lamps in a long street, we cannot judge of their proximity or remoteness but by the different quantities of light they transmit to the eye. Of course, if the lamps nearest the eye happen to be more obscure than those which are more remote, the first will appear to be last, and the last first.

CHAPTER V.

OF INFANCY.

By the term *Infancy*, is meant that portion of life which commences at birth, and terminates at that period when animals have acquired the power of self-preservation, without any assistance from their parents. This period varies greatly in different animals. Of course, when different species are mentioned, the term *infancy* must have very different limitations with regard to time.

The state of infancy, in the human species, continues longer than in any other animal. Infants, immediately after birth, are indeed extremely helpless, and require every assistance and attention from the mother. Most writers, however, on this subject, seem to have exaggerated not only the imbecility, but the miseries of the infant state.

Though infants remain longer in a state of imbecility than the young of other animals, they are by no means more helpless. The instant after birth, they are capable of sucking whatever is presented to their mouths. When in the same condition, the young of the opossum, of hares, rabbits, rats, mice, &c. can do no more. They can neither move nor support their bodies. Besides, many quadrupeds are destitute of the sense of seeing for several days after birth. But the faculty of vision is enjoyed by infants the moment after they come into the world. This faculty, in a few hours, becomes a great source of pleasure and amusement to them ; but it is denied, for some days, to many other species of animals. The young of most birds are equally weak and helpless as human infants. If infants really suffer more pain and misery than other animals in the same state, Nature seems not to merit that severity of censure which she has sometimes received. Men in society, like domestic animals, by luxury, by artificial modes of living, by unnatural and vicious habits, debilitate their bodies, and transmit to their progeny the seeds of weakness and disease, the effects of which are not felt by those who live more agreeably to the general economy and intentions of Nature. The children of savages, for the same reason, whether in the hunting or shepherd state, are more robust, more healthy, and liable to fewer diseases, than those produced by men in the more enlightened and refined stages of society. Even under the same governments, and in the same state of civilization, a similar gradation of imbecility and disease is to be observed. The children of men of rank and fortune are, in general, more puny, debilitated, and diseased, than those of the peasant or artificer. Still, however, children, in their progress from birth to maturity, have innumerable sources of pleasure, which alleviate, if they do not fully compensate, the pain which must unavoidably be endured, whether in a more natural or more artificial state of mankind. If luxury and civilization debilitate the constitutions of children, they give rise to many real enjoyments which are totally unknown to the savage. His wants are fewer; but his gratifications are more than proportionally diminished.

From what causes or circumstances particular modes in the management of infants originate, it is difficult to determine. But it is certain that savages, and the ruder nations, in their treatment of infants, often discover more discernment and propriety of conduct, than are to be found in the most polished stages of society. The negroes, the savages of Canada, of Virginia, of Brasil, and the natives of almost the whole of South America, lay their infants naked into hammocks, or hanging beds of cotton, or into cradles lined with fur. The Peruvians leave the arms of their infants perfectly loose in a kind of swathing-bag. When a little older, they are put, up to the middle, in a hole dug out of the earth, and lined with linen or cotton. By this contrivance, their arms and head are perfectly free, and they can bend their bodies, and move their arms and head, without the smallest danger of falling, or of receiving any injury. To entice them to walk, whenever they are able to step, the breast is presented to them at a little distance. The children of negroes, when very young, cling round, with their knees and legs, one of their mother's haunches, and grasp the breast with their hands. In this position they adhere so firmly, that they support themselves without any assistance, and continue to suck without danger of falling, though the mother moves forward, or works at her usual labour. These children, at the end of the second month, begin to creep on their hands and knees; and, in this situation, they acquire, by habit, the faculty of moving with surprising quickness.

Many savages are remarkably attentive to the cleanliness of their children. Though they cannot afford to change their furs so frequently as we do our linen, this defect they supply by other substances of no value. The savages of North America put wood-dust, obtained from decayed trees, into the bottom of the cradle, and renew it as often as it is necessary. Upon this powder the children are laid and covered with skins. This powder is very soft and quickly absorbs moisture of every kind. The children in Virginia are placed naked upon a board covered with cotton. This practice is, likewise, almost general in the eastern parts of Europe, and particularly in Turkey.

Many northern nations plunge their infants, immediately after birth, into cold water, without their receiving any injury. The Laplanders expose their new-born infants on the snow till they are almost dead with cold, and then throw them into a warm bath. During the first year, this seemingly harsh treatment is repeated three times every day. After that period, the children are bathed in cold water thrice every week. It is a general opinion in northern regions, that cold bathing renders men more healthy and robust; and hence they inure their children, from their very birth, to this habit.

With regard to the food of infants, it should consist, for the first few months, of the mother's milk alone. A child may be injured by allowing it, during that period, any other nourishment. In Holland, in Italy, in Turkey, and over the whole Levant, children, during the first year, are not permitted to taste any other food. The Canadian savages nurse their children four or five years, and sometimes six or seven. In cases of necessity, the milk of quadrupeds may supply that of the mother. But, in such cases, it is best the child should draw it from the animal; for the degree of heat is always uniform and proper, and the milk, by the action of the muscles, is mixed with the saliva, which is a great promoter of digestion. Several robust peasants have been known to have had no other nurses than ewes. After two or three months, children may be gradually accustomed to food somewhat more solid than milk. Before the teeth shoot through the gums, infants are incapable of mastication. During that period, therefore, it is obvious, that Nature intended they should be nourished solely by soft substances. But after they are furnished with teeth, it is equally obvious that they should occasionally be allowed food of a more solid texture.

The lives of children, during the first three or four years, are extremely precarious. After that period, their existence becomes gradually more certain. According to Simpson's tables of the degress of mortality in London at different ages, it appears, that, of a certain number of infants brought forth at the same time, more than a fourth part died the first year, more than a third in two years, and at least one half at the end of the third year. But the mortality of children is not nearly so great in every place; for, by a number of experiments made in France, it has been shown, that one half of the children born at the same time are not extinct in less than seven or eight years.

To treat of the diseases of children, or to enter minutely into the causes which contribute to the great mortality of mankind in early infancy, is no part of our plan. In general, these causes are to be referred to unnatural practices in the management of children, introduced by superstition, by ignorance, and by foolish notions arising from over-refinement, from prejudice, and from hypothetical systems, while the economy and analogy of Nature, in the conduct and situation of the inferior animals, are almost totally neglected. An infant is no sooner brought into the world, than it is crammed with physic. Nature's medicine for cleansing the bowels of infants, is the milk of the mother. But nurses absurdly imagine that drugs will answer this purpose much better. All other animals that give suck, nurse their own offspring; but we too frequently delegate this tender and endearing office to strange women, whose constitutions, habits of life, and mental dispositions, are often totally different from those of the genuine parent. Infants, recently after birth, frequently suffer from giving them, instead of the mother's milk, wine-whey, water-gruel, and similar unnatural kinds of nourishment. In this period of their existence, however, very little food, but a great deal of rest, is necessary for promoting their health, and securing their ease and tranquillity; for infants, when not teased by officious cares, sleep almost continually during several weeks after birth. Young animals are naturally fond of being in the open air; but our infants, particularly in large towns, are almost perpetually shut up in warm apartments, which both relaxes their bodies and enervates their minds. The great agility, strength, and fine proportions of savages, are results of a hardy education, of living much in the open air, and of an unrestrained use of all their organs the moment after they come into the world.

In young animals, as well as in infants, there is a gradual progress, both in bodily and mental powers, from birth to maturity. These powers are unfolded sooner or later, according to the nature and exigencies of particular species. This progress, in man, is very slow. Man acquires not his full stature and strength of body till several years after the age of puberty ; and, with regard to his mind, his judgment and other faculties cannot be said to be perfectly ripe before his thirtieth year.

In early infancy, though the impressions received from new objects must be strong, the memory appears to be weak. Many causes may concur in producing this effect. In this period of our existence, almost every object is new, and, of course, engrosses the whole attention. Hence the idea of any particular object is obliterated by the quick succession and novelty of others, joined to the force with which they act upon the mind. Haller ascribes this want of recollection to a weakness of memory ; but it seems rather to proceed from a confusion which necessarily results from the number and strong impressions of new objects. The memory ripens not so much by a gradual increase in the strength of that faculty, as by a diminution in the number and novelty of the objects which solicit attention. In a few years children are enabled to express all their wants and desires. The number of new objects daily diminishes, and the impressions made by those with which they are familiar, become comparatively small and uninteresting. Hence their habits of attention and the ardour of their minds begin to relax. Instead of a general and undistinguished gratification of their senses, this is the period when it is necessary to stimulate children, by various artifices, to apply their minds steadily to the examination of particular objects, and to the acquisition of new ideas from more complicated and refined sources of information. The great basis of education is a habit of attention. When this important point is gained, the minds of children may be moulded into any form. But that restlessness and appetite for motion, which Nature, for the wisest purposes, has implanted in the constitution of all young animals, should not be too severely checked. Health and vigour of body are the surest foundations of strength and improvement of mind.

The duration of infancy, from man to the insect tribes, seems, in general, to be proportioned, not to the extent of life, but to the sagacity or mental powers of the different classes of animated beings. The elephant requires thirty years, and the rhinoceros twenty, before they come to perfect maturity. But these years mark not the period of infancy; for the animals, in a much shorter time, are capable of procuring their own food, and are totally independent of any aid from their parents. The same remark is applicable to the camel, the horse, the larger apes, &c. Their ages of puberty are four, two and a half, and three years. But in these quadrupeds, the terminations of infancy are much more early. The smaller quadrupeds, as hares, rats, mice, &c. are mature at the end of the first year after birth; and the guinea-pig and rabbit require only five or six months. There is a gradation of mental powers, though not without exceptions, from the larger to the more minute quadrupeds; for the dog and fox, whose sagacity is very great, come to maturity in one year, and their state of infancy is short. But of all animals, the infancy and helpless condition of man are the most prolonged; and the superiority and ductility of his mind will not be questioned.

The infant state of birds is very short. Most of the feathered tribes arrive at perfection in less than six months; and their sagacity is comparatively limited.

Fishes receive no aid from their parents. They no sooner escape from the eggs of their mother, than they are in a condition to procure nourishment, and to provide, in some measure, for their own safety. Of the sagacity of fishes, owing to the element in which they live, we have very little knowledge. But their general character is stupidity, joined to a voracious and indiscriminating appetite for food. In opposition to an almost general law of Nature, which subsists among other animals, fishes devour, without distinction, every smaller or weaker animal, whether it belongs to a different species, or to their own. In animals of a much higher order, voracity of appetite is seldom accompanied with ingenuity or elegance of taste. When the principal attention of an animal is engrossed with any sensual appetite, it is a fair conclusion that the mental powers are weak, because they are chiefly employed upon the grossest of all objects. If this observation be just, fishes must be ranked among the most stupid animals of equal magnitude and activity.

The infant state of insects is a various and complicated subject. After they escape from the egg, they undergo so many changes, and assume such a variety of forms, that it is difficult to determine the period of their existence, which corresponds to the condition of infancy in the larger animals. Different kinds remain a longer or shorter time in the form of worms and chrysalids, and then of caterpillars, or grubs, before they are changed into flies. When young, like other animals, they are small and feeble; but even in their most helpless condition, with a very few exceptions, Nature is their only nurse. They require no aid from their parents, who, in general, are totally unacquainted with their progeny. But, as formerly observed when treating of instinct, the mothers uniformly deposit their eggs in situations which afford both protection and nourishment to their young. The parent fly, according to the species, invariably, unless restrained by necessity, deposits her eggs upon particular plants, in the bodies of other animals, in the earth, or in water. Whenever, therefore, an insect receives existence in its primary form, all its wants are supplied. Though the mother, after the worms issue from the eggs, takes no charge of her offspring, and frequently does not exist at the time they come forth, yet, by an unerring and pure instinct, she uniformly places them in situations where the young find proper nourishment, and every thing necessary to their feeble condition.

To this general law, by which insects are governed, there are several exceptions. Bees, and some other flies, not only construct nests for their young, but actually feed, and most anxiously protect them.

From what has been said concerning the infancy of animals, one general remark merits attention. Nature has uniformly, though by various modes, provided for the nourishment and preservation of all animated beings while they are in an infantine state. Though the human species continues long in that state, the attachment and solicitude of both parents, instead of abating, in proportion to the time and labour bestowed on their progeny, constantly augment, and commonly remain during life. The reciprocal affection of parents and children is one of the greatest sources of human happiness. If the love of children were not strong, and if it did not increase with time, the labour, the constant attention, the anxiety and fatigue of mothers would be insufferable. But here Nature, whose wisdom is always conspicuous, makes affection brave every difficulty, and sooth every pain. If a child be sickly, and require uncommon care, the exertions of the mother are wonderfully supported; pity unites with love; and these two passions become so strong, that hardships and fatigue of every kind, are suffered with cheerfulness and alacrity.

With regard to the inferior tribes of animals, Nature has not been less provident. To quadrupeds and birds, she has given a strong and marked affection for their offspring, as long as parental care is necessary. But whenever the young begin to be in a condition to protect and provide for themselves, the attachment of the parents gradually subsides; they become regardless of their offspring, at last banish them, with blows, from their presence, and, after that period, seem to have no knowledge of the objects which so lately engrossed all the attention of their minds, and occupied all the industry and labour of their bodies. Here the dignity and superiority of man appears in a conspicuous light. Instead of losing the knowledge of his offspring after they arrive at maturity, his affection expands, and embraces grandchildren, and great grandchildren, with equal warmth, as if they had immediately originated from himself.

CHAPTER VI.

OF THE GROWTH AND FOOD OF ANIMALS.

It is a law of nature, that all organized bodies, whether animal or vegetable, require food, in order to expand and strengthen their parts when young, and to preserve health and vigour after they have arrived at maturity. The food of animals is digested in the stomach and intestines; by this process, it is converted into chyle, and absorbed by the lacteal vessels, in the manner already described. But how this chyle or nutritious matter, after mingling with the general mass of blood, contributes to the growth and repairs the waste of animal bodies, is a mystery which probably never will be fully unfolded by human sagacity.

'Various theories have been invented by different philosophers, with a view to the explanation of this mystery, but they have either proved to be entirely without foundation on facts, or to be totally inadequate to account for the phenomena observed. Our knowledge concerning the nature of nutrition and growth, is extremely limited, and must continue to be so. We know that, in the animal kingdom, nutrition is performed by means of the blood, which is forcibly propelled through every part of the body by the action of the heart and arteries; and that vegetables, in a similar manner, are nourished by the ascension and distribution of the sap. But of the application of the nutritive particles to the various parts of organized bodies, and of the manner in which they expand the organs, or repair their continual waste and loss of substance, we must content ourselves with remaining in perpetual ignorance. It is however the opinion of the most rational and well informed physiologists, that the nutritious particles of food are conveyed by the arteries, and applied by their extremities to the various parts of animal bodies which require to be repaired or expanded.'

In general, the food of animals, and particularly of the human species, consists of animal and vegetable substances, combined with water, or other fluids. The Gentoo and some other southern nations, live entirely upon vegetable diet. From the accounts we have of the different regions of the earth, it appears, that the natives of warm climates, where the cultivation of plants is practised, employ a greater proportion of vegetable food than in the more northern countries. The inhabitants of Lapland have little or no dependence on the fruits of the earth. They neither sow nor reap. They still remain, and, from the nature of their climate, must forever remain in the shepherd state. Their comparative riches consist entirely of the number of rein-deer possessed by individuals. Their principal nourishment is derived from the flesh and milk of these animals. In autumn, however, they catch great multitudes of fowls, most of them of the game kind. With these, while fresh, they not only supply their present wants, but dry and preserve them through the winter. They likewise kill hares, and other animals, which abound in the woods and mountains; but the flesh of the bear is their greatest delicacy. In their lakes and rivers, they have inexhaustible stores of fish, which, in summer and autumn, they dry in the sun, or in stoves, and in winter preserve by the frost. The Laplanders drink water, or animal oils; but never taste bread or salt. They live in a pure air, and have sufficient exercise. Their constitutions are attempered to the coldness of the climate; and they are remarkable for vigour and longevity. The gout, the stone, the rheumatism, and many other diseases which torture the luxurious in milder climes, are totally unknown to them. With the few gifts which Nature has bestowed on them, they remain satisfied, and live happily among their mountains and their storms. If southern nations afford examples of people who feed nearly on vegetables alone, the Laplanders furnish one of the opposite extreme; for they are almost entirely carnivorous.

To Norway, Sweden, Germany, Britain, and the United States, the same observation is applicable. In these countries animal food is much more used than in France, Spain, Italy, Barbary, and the other southern regions of the globe. Many reasons may be assigned for these differences in the food of nations. The natural productions of the earth depend entirely on the climate. In warm climates, the vegetables which grow spontaneously are both more luxuriant and more various. Their fruits, in number and richness, far exceed those of colder regions. From this circumstance, the natives must be stimulated to use a proportionally greater quantity of vegetable food; and we learn from history, and from travellers, that this is actually the case. In cold countries, on the contrary, vegetables are not only fewer, but more rigid, and contain less nourishment. The inhabitants, accordingly, are obliged to live principally on animal substances. If we examine the mode of feeding in different nations, it will be found, that in proportion as men approach or recede from the poles, a greater or less quantity of animal and vegetable substances are used in their diet. Custom, laws, and religious rites, it must be allowed, produce considerable differences in the articles of food, among particular nations, which have no dependence on climate, or the natural productions of the earth. But when men are not fettered or prejudiced by extraneous circumstances, or political institutions, the nature of their food is invariably determined by the climates they inhabit. The variety of food, in any country, is likewise greatly influenced by culture and by imitation. Commerce occasionally furnishes new species of food, particularly of the vegetable kind. In Scotland, till about the beginning of this century, the common people lived almost entirely upon grain. Since that period, the culture and use of the potato, of many species of coleworts, and of fruits, have been introduced, and universally diffused through the nation.

Whether man was originally intended by Nature to live solely upon animal or vegetable food, is a question which has been much agitated both by the ancients and the moderns. Many facts and circumstances concur in establishing the opinion, that man was designed to be nourished neither by animals nor vegetables solely, but by a mixture of both. Agriculture is an art the invention of which must depend on a number of fortuitous circumstances. It requires a long succession of ages before savage nations learn this art. They depend entirely for their subsistence upon hunting wild animals, fishing, and such fruits as their country happens spontaneously to produce. This has uniformly been the manner of living among all the savage nations of which we have any proper knowledge; and seems to be a clear proof, that animal food is by no means repugnant to the nature of man. Besides, the surface of the earth, even in the most luxuriant climates, and though assisted by culture, is not capable of producing vegetable food in sufficient quantity to support the human race, after any region of it has become so populous as Britain, France, and many other nations. The general practice of mankind, when not restrained by prejudice or superstition, of feeding promiscuously on animal and vegetable substances, is a strong indication, that man is, partly at least, a carnivorous animal. The Gentoos, though their chief diet be vegetables, afford no proper argument against this reasoning. They are obliged, by their religion, to abstain from the flesh of animals; and they are allowed to use milk, which is a very nourishing animal food. Notwithstanding this indulgence, the Gentoos in general are a meagre, sickly, and feeble race. In hot climates, however, a very great proportion of vegetable diet may be used without any bad consequences.

Other arguments, tending to the same conclusion, are derived, not from the customs or practices of particular nations, but from the structure of the human body. All animals which feed upon vegetables alone, as formerly remarked, have stomachs and intestines proportionally larger than those that live solely on animal substances. Man, like the carnivorous tribes, is furnished with cutting and canine teeth, and, like the graminivorous, with a double row of grinders. The dimensions of his stomach and intestines likewise hold a mean proportion between these two tribes of animals, which differ so essentially in their characters and manners. From these and similar arguments, I have no hesitation to conclude, that a promiscuous use of animal and vegetable substances is no deviation from the original nature or destination of mankind, whatever country they may inhabit.

With regard to the different proportions of animal and vegetable food which are most accommodated to the health and vigour of mankind, no general rule can be given that could be applicable to different climates, and to the different constitutions of individuals. Animal food, it is certain, gives vigour to the body, and may be used more liberally by the active and laborious than by those who lead a studious and sedentary life. A great proportion of vegetable food, and particularly of bread, is considered by the most eminent physicians, as best adapted for men who are fond of science and literature; for, full meals of animal food load the stomach, and seldom fail to produce dulness, yawning, indolence, and many diseases which often prove fatal.

'Man is directed in the selection of his food, partly by accident, and partly by experience and the aid of his senses. That which is pleasant to his palate, is generally salutary to his stomach; and by a constant observation of the effects produced by different kinds of food, he acquires a considerable facility in determining what is proper.' Other animals select their food instinctively; and their choice is chiefly determined by the sense of smelling. The spaniel hunts his prey by the scent; but the greyhound depends principally upon the use of his eye. When the greyhound loses sight of a hare, he instantly gives up the chace, and looks keenly around him, but never applies his nose, in order to discover the track. Some rapacious animals, as wolves and ravens, discover carrion at distances, which, if we were to judge from our own sense of smelling, would appear to be altogether incredible. Others, as eagles, hawks, gulls, &c. surprise us no less by the acuteness of their sight. They perceive, from great heights in the air, mice, small birds, and minute fishes in the water.

One great cause of the diffusion of animals over every part of the globe, is to be derived from the diversity of appetites for particular species of food, implanted by nature in the different tribes. Some fishes are only to be found in certain latitudes. Some animals inhabit the frigid, others the torrid zone; some frequent deserts, mountains, woods, lakes, and meadows. In their choice of situation, they are uniformly determined to occupy such places as furnish them with food accommodated to their natures. Monkeys, the elephant, and rhinoceros, fix on the torrid zone, because they feed on vegetables which flourish there during the whole year. The rein-deer inhabit the cold regions of the north, because these countries produce the greatest quantity of the lichen, a species of moss, which is their beloved food. The pelican makes choice of dry and desert places to lay her eggs. When her young are hatched, she is obliged to bring water to them from great distances. To enable her to perform this necessary office, nature has provided her with a large sack, which extends from the tip of the upper mandible of her bill to the throat, and holds as much water as will supply her brood for several days. This water she pours into the nest to cool her young, to allay their thirst, and to teach them to swim. Lions, tigers, and other rapacious animals, resort to these nests, drink the water, and are said not to injure the young. The goat ascends the rocky precipice, to crop the leaves of shrubs and other favorite plants. The sloth and the squirrel feed upon the leaves and the fruit of trees, and are, therefore, furnished with feet which enable them to climb. Water-fowls live upon fishes, insects, and the eggs of fishes. Their bill, neck, wings, legs, and whole structure, are nicely fitted for enabling them to catch the food adapted to their natures. Their feeding upon the eggs of fishes, accounts for that variety of fishes which are often found in lakes and pools on the tops of hills, and on high grounds remote from the sea and from rivers. The bat and the goat-sucker fly about during the night, when the whole air is filled with moths and other nocturnal insects. The bear, who acquires a prodigious quantity of fat during the summer, retires to his den, when provisions fail him, in winter. For some months, he receives his sole nourishment from the absorption of the fat which had been previously accumulated in the cellular membrane.

A glutton, brought from Siberia to Dresden, eat every day says M. Klein, thirty pounds of flesh without being satisfied. This fact indicates an amazing digestive power in so small a quadruped; for the story of his squeezing his sides between two trees, in order to make him disgorge, is a mere fable.

Siberia, Kamtschatka, and the polar regions are supposed to be the abodes of misery and desolation. They are, it must be allowed, infested with numerous tribes of bears, foxes, gluttons, and other rapacious animals. But it should be considered, that these voracious animals supply the natives with both food and clothing. To elude the attacks of ferocity, and to acquire possession of the skins and carcasses of such creatures, the industry and dexterity of savage nations are excited. The furs are demanded by foreigners. The inhabitants by this means learn commerce and the arts of life; and in the progress of time, bears and wild beasts become the instruments of polishing a barbarous people. Thus the most substantial good often proceeds from apparent misfortune.

There is hardly a plant that is not rejected as food by some animals, and ardently desired by others. The horse yields the common water-hemlock to the goat, and the cow the long-leafed water-hemlock to the sheep. The goat, again, leaves the aconite, or bane-berries, to the horse, &c. Plants which afford proper nourishment to some animals, are by others avoided, because they would not only be hurtful, but even poisonous. Hence no plant is absolutely deleterious to animal life. Poison is only a relative term. The euphorbia, or spurge, so noxious to man, is greedily devoured by some of the insect tribes.

It is a remark of the ingenious Reaumur, that such insects as feed upon dead carcasses, and whose fecundity is great, never attack live animals. The flesh-fly deposits her eggs in the bodies of dead animals, where her progeny receive that nourishment which is best suited to their constitution. But this fly never attempts to lay her eggs in the flesh of sound and living animals. If Nature had determined her to observe the opposite conduct, men, quadrupeds, and birds would have been dreadfully afflicted by the ravages of this single insect. Lest it might be imagined that the flesh-fly selected dead, instead of live animals, because, in depositing her eggs, she was unable to pierce the skin of the latter, M. de Reaumur made the following experiment, which removed every doubt that might arise on the subject. He carefully pulled off all the feathers from the thigh of a young pigeon, and applied to it a thin slice of beef, in which there were hundreds of maggots. The portion of beef was not sufficient to maintain them above a few hours. He fixed it to the thigh by a bit of gauze;

and he prevented the pigeon from moving, by tying its wings and legs. The maggots soon shewed that their present situation was disagreeable to them. Most of them retired from under the slice of beef; and the few that remained perished in a short time. Their death was probably occasioned by the degree of heat in the pigeon's body being greater than their constitution could bear. Upon the same pigeon M. de Reaumur performed another experiment. He took off the skin from its thigh, laid bare the flesh, and applied immediately another slice of beef full of maggots. The animals discovered evident marks of uneasiness; and all of them that remained on the flesh of the pigeon were deprived of life, as in the former experiment, in less than an hour. Thus the degree of heat that is necessary to such worms as inhabit the interior parts of animals, is destructive to those species which nature has destined to feed upon the flesh of dead animals. Hence the worms sometimes found in ulcerous sores, must belong to a different species from those upon which the above experiments were made.

The growth of some worms, which feed upon animal or vegetable substances, is extremely rapid. Redi remarked, that these creatures, the day after they escaped from the egg, had acquired at least double their former size. At this period he weighed them, and found that each worm weighed seven grains; but that, on the day preceding, it required from twenty-five to thirty of them to weigh a single grain. Hence, in about the space of twenty-four hours, each of these worms had become from one hundred and fifty-five to two hundred and ten times heavier than formerly. This rapidity of growth is remarkable in those maggots which are produced from the eggs of the common flesh-fly.

Before we dismiss this subject, a few observations on that power inherent in all animal bodies, of dissolving, and converting into chyle, the nutritive substances thrown into the stomach, merit attention.

In order to explain the process of digestion, some physicians and philosophers have had recourse to mechanical force, and others to chemical action. The supporters of mechanical force maintained, that the stomachs of all animals comminuted, or broke down into small portions, every species of food, and prepared it for being converted into chyle. The chemical philosophers, on the contrary, supported the opinion, that the food was dissolved by a fermentation induced by the saliva and gastric juices. The disputes which naturally arose from these seemingly opposite theories, stimulated the inquiries of the ingenious, and produced several curious and important discoveries.

'Many physiologists have exerted their industry upon this subject, but it would require more space than the design of this work will allow, to give even an abridged account of all their labours. Therefore, only some of the most curious and important results will be presented.

'Spallanzani, who made a great number of original observations and experiments upon digestion, directed his attention to this function, as taking place in animals with three different kinds of stomach 1. Those with strong muscular stomachs or gizzards, as hens, turkeys, ducks, geese, pigeons, &c. 2. Those with stomachs of an intermediate structure, as crows, herons, &c. 3. Those with membranous stomachs, as man, the mammalia, many birds, particularly the accipitrine, reptiles, and fishes.

'1. In his experiments upon birds with strong gizzards, Spallanzani forced down their throats small glass and metal balls and tubes, filled with grain, and perforated with many holes in order to give free admittance to the gastric juice. The grain was in its entire state. At the end of different periods varying from twenty-four to forty-eight hours, the animals were killed and the balls examined. No change had taken place in the grain. There was no diminution of size, and no marks of dissolution were to be seen. In all his experiments, which were numerous, the event was uniformly the same. Suspecting that, although the gastric juice might be unable to dissolve grains in their entire state, it might act as a solvent upon them when sufficiently masticated or bruised, he repeated his experiments, filling his balls with bruised grain. In all his numerous trials upon this plan, he invariably found, that the grain was more or less dissolved in proportion to the time the balls were allowed to remain in the stomach.

'When tin tubes full of grain were thrust into the stomachs of turkeys, and allowed to continue there a considerable time, they were found to be broken, crushed, and distorted in such a manner as to evince the existence of a most powerful comminuting force.' "Having found," says Spallanzani, "that the tin tubes which I used for common fowls were incapable of

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resisting the stomach of turkeys, and not happening at that time to be provided with any tin plate of greater thickness, I tried to strengthen them, by soldering to the ends two circular plates of the same metal, perforated only with a few holes for the admission of the gastric fluid. But this contrivance was ineffectual; for after the tubes had been twenty hours in the stomach of a turkey, the circular plates were driven in, and some of the tubes were broken, some compressed, and some distorted, in the most irregular manner."

'These smooth substances, although so violently acted upon, could not injure the stomach, and Spallanzani was therefore induced to try the effect of sharp bodies. He found that the stomach of a cock in twenty-four hours broke off the angles of a piece of rough, jagged glass, without laceration or wound. A leaden ball into which twelve strong tin needles were firmly fixed, with their points projecting about a quarter of an inch from the surface, was then covered with a case of paper and forced down the throat of a turkey. The animal discovered no symptoms of uneasiness, and at the end of a day and a half, when the stomach was examined, the points of the twelve needles were broken off close to the surface of the ball, except two or three, which projected a little. Two of these points were discovered among the food, the other ten had probably passed out of the body.

'In another experiment still more cruel than this, twelve small lancets were fixed in a similar manner, into a leaden ball, and forced down the throat of a turkey cock. After eight hours the stomach was opened, but nothing appeared except the naked ball, the lancets having been broken to pieces. The stomach itself was found perfectly sound and uninjured in both these experiments.

'It is common in the gizzards of many birds, to find small stones, which have been supposed to assist in breaking down grain and other hard substances into small fragments, to prepare the way for their digestion. Spallanzani has endeavoured to prove that the muscular action of the gizzard is equally powerful without the stones. In a number of pigeons which he had fed from the egg himself, so as to prevent them from obtaining stones, he found that tin tubes, glass globules, and fragments of broken glass, were acted upon in the same way as in ordinary circumstances; and this happened also without any laceration of the stomach. It is the opinion, however, of the best physiologists, notwithstanding these experiments, that stones are extremely useful in the comminution of grain, and other substances which constitute the food of fowls, though not absolutely essential.

'2. In stomachs of an intermediate kind, such as those of crows, ravens, &c. the power and action of their coats upon substances contained within them, were found to be greatly inferior to those of the strong muscular stomachs. But little alteration was produced upon the tubes of tin, but when made of lead, they were evidently compressed and flattened. When unbroken grains and seeds were enclosed in perforated tubes and thrust into their stomachs, no change whatever was produced, no solution appeared to have taken place. But when the same substances were bruised into a coarse flour, so as to get rid of their husks, a very sensible diminution of their bulk took place, and on being several times introduced, they were finally entirely dissolved. Wheat and beans, when eaten voluntarily by the crow, offered similar phenomena. Before swallowing, the animal set them under its feet, and broke them in pieces by repeated strokes of its beak; and then they were very well digested. But when the same seeds were swallowed entire, they were generally vomited up, or voided unaltered. Similar experiments were made with French beans, pease, nut kernels, bread, apples, and different kinds of flesh and fish; and corresponding results were obtained.'

3. Spallanzani finished his experiments on digestion with those animals which have thin membranous stomachs, as man, quadrupeds, fishes, reptiles, and some birds. In these, the coats of the stomach seemed to have little or no mechanical action upon their contents; the gastric juice being fully sufficient to break down the food, and reduce it to a pulp.

With regard to man, Dr Stevens, in an Inaugural Dissertatation concerning digestion, published at Edinburgh in the year 1777, made several experiments upon a German, who gained a miserable livelihood by swallowing stones for the amusement of the people. He began this strange practice at the age of seven, and had at that time continued it about twenty years. He swallowed six or eight stones at a time, some of them as large as a pigeon's egg, and passed them in the natural way. Dr Stevens thought this poor man would be an excellent subject for ascertaining the solvent power of the gastric juice in the human stomach. The Doctor, accordingly, made use of him for this purpose. He made the German swallow a hollow silver sphere, divided into two cavities by a partition, and perforated with a great number of holes, capable of admitting an ordinary needle. Into one of these cavities he put four scruples and a half of raw beef, and into the other five scruples of raw bleak. In twenty-one hours the sphere was voided, when the beef had lost a scruple and a half, and the fish two scruples. A few days afterwards, the German swallowed the same sphere, which contained, in one cavity, four scruples and four grains of raw, and, in the other, four scruples and eight grains of boiled beef. The sphere was returned in forty-three hours; the raw flesh had lost one scruple and two grains, and the boiled one scruple and sixteen grains. Suspecting that, if these substances were divided, the solvent would have a freer access to them, and more of them would be dissolved, Dr Stevens procured another sphere, with holes large enough to receive a crow's quill. He inclosed some beef in it a little masticated. In thirty-eight hours after it was swallowed, it was voided quite empty. Perceiving how readily the chewed meat was dissolved, he tried whether it would dissolve equally soon without being chewed. With this view, he put a scruple and eight grains of pork into one cavity, and the same quantity of cheese into the other. The sphere was retained in the German's stomach and intestines forty-three hours; at the end of which time, not the smallest quantity of either pork or cheese was to be found in the sphere. He next swallowed the same sphere, which contained, in one partition, some roasted turkey, and some boiled salt herring in the other. The sphere was voided in forty-six hours; but no part of the turkey or herring appeared; for both had been completely dissolved. Having discovered that animal substances, though inclosed in tubes, were easily dissolved by the gastric juice, the Doctor tried whether it would produce the same effect upon vegetables. He, therefore, inclosed an equal quantity of raw parsnip and potato in a sphere. After continuing forty-eight hours in the alimentary canal, not a vestige of either remained. Pieces of apple and turnip, both raw and boiled, were dissolved in thirty-six hours.

It is a comfortable circumstance that no animal, perhaps, except those worms which are generated in the human intestines, can resist the dissolving power of the gastric juice. Dr Stevens inclosed live leeches, and earth-worms, in different spheres, and made the German swallow them. When the spheres were discharged, the animals were not only deprived of life, but completely dissolved, by the operation of this powerful menstruum. Hence, if any live reptile should chance to be swallowed, we have no reason to apprehend any danger from such an accident.

The German left Edinburgh before the Doctor had an opportunity of making a farther progress in his experiments. He therefore had recourse to dogs and ruminating animals. In the course of his trials upon the solvent power in the gastric fluid of dogs, he found that it was capable of dissolving hard bones, and even balls of ivory; but that, in equal times, very little impression was made upon potatoes, parsnips, and other vegetable substances. On the contrary, in the ruminating animals, as the sheep, the ox, &c. he discovered that their gastric juice speedily dissolved vegetables, but made no impression on beef, mutton, and other animal bodies. From these last experiments, it appears, that the different tribes of animals are not less distinguished by their external figure, and by their manners, than by the quality and powers of their gastric juices. Dogs are unable to digest vegetables, and sheep and oxen cannot digest animal substances. As the gastric juice of the human stomach is capable of dissolving, nearly with equal ease, both animals and vegetables, this circumstance affords a strong, and almost an irresistible proof, that Nature originally intended man to feed promiscuously upon both.

Live animals, as long as the vital principle remains in them, are not affected by the solvent powers of the stomach. "Hence it is," Mr Hunter remarks, "that we find animals of various kinds living in the stomach, or even hatched and bred there; but the moment that any of these lose the living principle, they become subject to the digestive powers of the stomach. If it were possible, for example, for a man's hand to be introduced into the stomach of a living animal, and kept there for some considerable time, it would be found, that the dissolvent powers of the stomach could have no effect upon it; but if the same hand were separated from the body, and introduced into the same stomach, we should then find, that the stomach would immediately act upon it. Indeed, if this were not the case, we should find that the stomach itself ought to have been made of indigestible materials; for, if the living principle was not capable of preserving animal substances from undergoing that process, the stomach itself would be digested. But we find, on the contrary, that the stomach which at one instant, that is, while possessed of the living principle, was capable of resisting the digestive powers which it contained, the next moment, viz. when deprived of the living principle, is itself capable of being digested, either by the digestive powers of other stomachs, or by the remains of that power which it had of digesting other things."

When bodies are opened some time after death, a considerable aperture is frequently found at the greatest extremity of the stomach. "In these cases," says Mr Hunter, "the contents of the stomach are generally found loose in the cavity of the abdomen, about the spleen and diaphragm. In many subjects, this digestive power extends much farther than through the stomach. I have often found, that, after it had dissolved the stomach at the usual place, the contents of the stomach had come into contact with the spleen and diaphragm, had partly dissolved the adjacent side of the spleen, and had dissolved the stomach quite through; so that the contents of the stomach were found in the cavity of the thorax, and had even affected the lungs in a small degree."

CHAPTER VII.

OF THE TRANSFORMATION OF ANIMALS.

The transformation of caterpillars, and of different kinds of worms, into winged insects, has long excited the attention, as well as the admiration of mankind. But the truth is, that every animal, without exception, undergoes changes in structure, mode of existence, and external appearances. Mankind, from their embryo state, to their final dissolution, assume many different forms. At birth, the form, symmetry, and organs of the animal are by no means complete. The head continues for some time to be disproportionally large; the hands and feet are not properly shaped; the legs are crooked; the hair on the head is short and scanty; no teeth as yet appear; and there is not a vestige of a beard. In a few months, however, the symmetry of all the parts is evidently improved, and the teeth begin to shoot. The growth of the whole body, as well as the strength and beauty of its form, gradually advances to perfection till the sixth or seventh year, when another change takes place. At this period, the first set of teeth are shed, and are replaced by new ones. From boyhood to youth, the size of the body, and of its different members, increases. During youth, several important changes are produced in the system. The beard now makes its appearance; and the dimensions of the body, in most individuals, are suddenly augmented. From this period, to the age of twenty-five or thirty, the muscles swell, their interstices are filled with fat, the parts bear a proper proportion to each other, and man may now be considered as a perfect animal. In this state of bodily perfection and vigour, he generally remains till he reaches his fiftieth year. Then a new but a gradual change begins to appear. From the fiftieth year to the age of seventy or eighty, the powers of the body decline in their strength and activity. The muscles lose their spring and their force. The vigour of manhood is no longer felt, and the withered decrepitude of old age is succeeded by death, its unavoidable consequence.

The mind of man undergoes changes as well as his body. The taste, the appetites, and the dispositions are in perpetual fluctuation. How different is the taste of a child from that of a man! Fond of gewgaws and of trifling amusements, children frolic away their time without much thought or reflection. When advancing towards youth, their dispositions and desires suffer a gradual mutation. The faculties are unfolded, and a sense of propriety begins to be perceived. They despise their former occupations and amusements; and different species of objects solicit and obtain their attention. Their powers of reflection are now considerably augmented; and both sexes acquire a modesty and a shyness with regard to each other. This awkward, but natural bashfulness, by the intercourse of society, soon vanishes. From this period to the age of twenty-five or thirty, men's minds assume a bold, enterprising, and active tone. They engage in the business of life, look forward to futurity, and have a desire of marrying and of establishing families. All the social appetites are in vigour; solid and manly friendships are formed; and man goes on for some time to enjoy every kind of happiness which his nature is capable of affording. At fifty or sixty, the mental powers, in general, like those of the body, begin to decline, till feeble and tremulous old age arrives, and death closes the mutable scene of human life.

With regard to quadrupeds, both before and after birth, they undergo similar, and many of them greater, changes of form than those of the human species. Their mental powers, likewise, their dispositions and manners, as well as the objects of their attention, vary according to the different stages of their existence. Many of them come into the world blind, and continue for some time before they receive the sense of seeing. How many changes are exhibited in the dog from birth till he becomes a perfect animal, till all his members are completely formed, and all his instincts are unfolded and improved by experience and education. The deer kind acquire not their magnificent and beautiful horns before the age of puberty; and even these are annually cast off and renewed. Similar changes take place in quadrupeds of every denomination; with examples of which every man's experience and recollection will readily supply him; and, therefore, it is unnecessary to be more particular.

Neither are birds, in their progress from birth to maturity, exempted from changes. Like quadrupeds, many birds are blind for some time after they are hatched. In this condition, how different are their form and appearances from those of the perfect animals! At first, they are covered with a kind of down instead of feathers. Even after the feathers shoot, they are often of a colour different from that which they acquire when full grown. The beautifully variegated colours of the peacock's tail appear not till he arrives at his third year. Birds that have crests or wattles, live a considerable time before they acquire these ornaments or marks of distinction. All birds annually moult, or cast their feathers, in the same manner as quadrupeds shed their hair; the new pushing out the old.

Frogs, toads, and some other reptiles undergo great changes in their form and structure. When it first escapes from the egg, a frog appears in the form of a tadpole, an animal with a large, roundish head, and a compressed or flat tail, but totally destitute of feet and legs. In this state it remains a considerable time, when the two fore feet begin to shoot, and have an exact resemblance to the buds of trees. As their growth advances, the toes and legs are distinguishable. The same process goes on with the hind legs, only they are somewhat later in making their appearance. During the growth of the legs, the blood being drawn into different channels, the tail suffers a gradual mortification, till at last it totally vanishes and the tadpole is metamorphosed into a quadruped. Tadpoles never come out of the water; but after their transformation into frogs, they become amphibious, and occasionally frequent both land and water.

'In the species of frog called Rana paradoxa, or the paradoxical frog, the animal in its tadpole state grows to its full size, before the change takes place. Having in almost all respects the appearance of a fish, it has been supposed by the vulgar to be a frog turned into a fish. and hence has been called the frog-fish. In time, however, it undergoes the usual changes, and becomes a true frog. It inhabits Surinam. In a species of toad, also found in Surinam, the whole process of metamorphosis, from the egg to the perfect state, is carried on upon the back of the parent animal. The egg is deposited under the skin, and as the successive changes take place, the sack in which it is contained, is enlarged to accommodate its increasing size.'

Serpents cast their skins annually. The beauty and lustre of their colours are then highly augmented. Before casting, the old skins have a tarnished and withered appearance. The old skins, like the first set of teeth in children, are forced off by the growth of the new.

The crustaceous tribes, as lobsters, crabs, &c. beside the different appearances they assume while growing to perfection, cast their shells every year. When this change is about to happen, they retire into the crevices of rocks, or shelter themselves below detached stones, with a view to conceal and defend their bodies from the rapacious attacks of other fishes. After the shells are cast, the animals are exceedingly weak and defenceless. Instead of their natural defence of hard shells and strong claws, they are covered only with a thin membrane or skin. In this state they become an easy prey to almost every fish that swims. The skin, however, gradually thickens and grows harder, till it acquires the usual degree of firmness. By this time the animals have resumed their former strength and activity; they come out from their retirements, and go about in quest of food.

We come now to give some account of the transformations of Insects, which are both various and wonderful. All winged insects, without exception, and many of those which are destitute of wings, must pass through several changes before the animals arrive at the perfection of their natures. The appearance, the structure, and the organs of a caterpillar, of a chrysalis, and of a fly, are so different, that, to a person unacquainted with their transformations, an identical animal would be considered as three distinct species. Without the aid of experience, who could believe that a butterfly, adorned with four beautiful wings, furnished with a long spiral proboscis or tongue, instead of a mouth, and with six legs, should have proceeded from a disgusting, hairy caterpillar, provided with jaws and teeth, and fourteen feet? Without experience, who could imagine that a long, white, smooth, soft worm, hid under the earth, should be transformed into a black, crustaceous beetle, having wings covered with horny elytra, or cases?

Upon this branch of the subject, we shall, *first*, give an example of two of the most common transformations of insects; and, *secondly*, describe some of the more uncommon kinds. Beside their final metamorphosis into flies, caterpillars undergo several intermediate changes. All caterpillars cast or change their skins oftener or more seldom, according to the species. Malpighius informs us, that the silkworm, previous to its chrysalis state, casts its skin four times. The first skin is cast on the 10th, 11th, or 12th day, according to the nature of the season; the second in five or six days after; the third in five or six days more; and the fourth and last in six or seven days after the third. This changing of skin is not only common to all caterpillars, but to every insect whatever. Not one of them arrives at perfection without casting its skin at least once or twice. The skin, after it is cast, preserves so entirely the figure of the caterpillar in its head, teeth, legs, colour, hair, &c. that it is often mistaken for the animal itself. A day or two before this change happens, caterpillars take no food; they lose their former activity, attach themselves to a particular place, and bend their bodies in various directions, till at last they escape from the old skin, and leave it behind them. When about to pass into the chrysalis state, which is a state of imbecility, caterpillars select the most proper places and modes of concealing themselves from their enemies. Some, as the silkworm, and many others, spin silken webs round their bodies, which completely disguise the animal form. Others leave the plants upon which they formerly fed, and hide themselves in little cells which they make in the earth. The rat-tailed worm abandons the water upon the approach of its metamorphosis, retires under the earth, where it is changed into a chrysalis, and, after a certain time, bursts from its seemingly inanimate condition, and appears in the form of a winged insect. Thus the same animals pass the first and longest period of their existence in the water, another under the earth, and the third and last in the air. Some caterpillars, when about to change into the chrysalis state, cover their bodies with a mixture of earth and of silk, and conceal themselves in the loose soil. Others incrust themselves with a silky or glutinous matter, which they push out from their mouths, without spinning it into threads. Others retire into the holes of walls or of decayed trees. Others suspend themselves to the twigs of trees, or to other elevated bodies, with their heads undermost. Some attach themselves to walls, with their heads higher than their bodies, but in various inclinations; and others choose a horizontal position. Some fix themselves by a gluten, and spin a rope round their middle to prevent them from falling. Those which feed upon trees attach themselves to the branches, instead of the leaves, which are less durable, and subject to a greater variety of accidents. The colours of the caterpillars give no idea of those of the future flies.

In general, the figure of chrysalids approaches to that of a cone, especially in their posterior part. When under this form, the insect seems to have neither legs nor wings. It is incapable either of walking or of crawling. It takes no nourishment, because it has no organs suited to that purpose; yet, in some species, life is continued for several months before their last metamorphosis takes place. In a word, it seems to be a lifeless mass. But upon a more attentive observation, it is found to possess the power of bending upwards and downwards the posterior part of its body. The skin, or exterior covering of those which do not spin webs, seems to be of a cartilaginous nature. It is commonly smooth and shining. In some species, however, the skin of the chrysalis is more or less covered with hair, and other rugosities. Though chrysalids differ both in figure and colour, their appearances are by no means so various as those of the caterpillars from which they are produced. The colour of some chrysalids is that of pure gold, from which circumstance the whole have received their denomination. For the same reason they are called *aureliæ* in Latin. Some are brown, others green; and, indeed, they are to be found of almost every colour and shade.

The life of winged insects consists of three principal periods, which present very different scenes to the student of nature. In the first period, the insect appears under the form of a worm, caterpillar, or larva. Its body is long and cylindrical, and consists of a succession of rings, which are generally membranous, and incased within each other. By the aid of its rings, or of crotchets, or of several pairs of legs, it crawls about in quest of food; and its movements are, in some species, remarkably quick. Its head is armed with teeth, or pincers, by which it eats the leaves of plants or other kinds of food. Its blood moves from the tail toward the head. It respires either by stigmata or small apertures placed on each side of its body, or by one or several tubes situated on its posterior part, which have the resemblance of so many tails. In the second period, the insect appears under the form of a nymph, or a chrysalis. While in this state, insects in general are totally inactive, and seem not to possess any powers of life. Sunk into a kind of deep sleep, they are little affected by external objects. They can make no use of their eyes, their mouth, or any of their members; for they are all imprisoned by coverings more or less strong. No cares occupy their attention. Deprived of the faculty of motion, they remain fixed in those situations which they have chosen for their temporary abode, or where chance has placed them, till their final metamorphosis into flies. Some of them, however, are capable of changing place; but their movements are slow and p inful. Their blood circulates, but in a contrary direction from what takes place in the caterpillar state; for it proceeds from the head toward the tail. Respiration continues to go on, but the organs are differently situated. In the caterpillar, the principal organs of respiration were placed at the posterior part of the body; but now these same organs are to be found at the anterior part of the animal. In the third period, the insect has acquired that perfect organization which corresponds to the rank it is to hold in the scale of animation. The bonds of the nymph, or of the chrysalis, are now burst asunder, and the insect commences a new mode of existence. All its members, formerly soft, inactive, and folded up in an envelope, are expanded, strengthened, and exposed to observation. Under the form of a worm or caterpillar, it crawled; under that of a nymph or chrysalis, its power of motion was almost annihilated; under the last form, it is furnished with six springy legs, and two or four wings, with which it is enabled to fly through the air. Instead of teeth or pincers, with which it divided a gross aliment, it has now a trunk, by which it extracts the refined juices of the most delicate flowers. Instead of a few smooth eyes which it possessed in the worm and caterpillar state, the new insect is furnished with both smooth and convex eyes, to the number of several thousands.

The internal parts of the insect have likewise undergone as many changes as the external. The texture, the proportions, and the number of the viscera, are greatly altered. Some have acquired an additional degree of consistence; others, on the contrary, are rendered finer and more delicate. Some receive a new form, and others are entirely annihilated. Lastly, some organs in the perfect insect, which seemed formerly to have no existence, are unfolded, and become visible.

We shall now give some examples of transformations which deviate from the common mode.

Some insects hold a middle rank between those which preserve their original figure during life, and those that suffer transformations. Their existence is divided into two periods only. They walk in the first, and fly in the second. Thus their only metamorphosis consists of the addition of wings, the growth and expansion of which are performed without any considerable alteration in the figure of their bodies.

There is not a law established among organized bodies which seems to be so universal, as that all of them grow or augment in size, after birth, till they arrive at maturity. If a hen were to bring forth an egg as large as her own body, and if this egg, when hatched, were to produce a bird of equal dimensions with either of the parents, it would be considered as a miracle. But the *spider-fly*, so denominated from its figure, affords an example of a similar prodigy. This fly actually lays an egg, from which a new fly is hatched that is as large and as perfect as its mother. This egg is roundish, is at first white, and afterwards assumes a shining black colour. Upon a more accurate examination, however, this production is found to be an egg only in appearance. When the envelope is removed, instead of a gelatinous substance, the new insect, furnished with all its members, is discovered. But this discovery does not render the fact the less wonderful. All winged insects undergo their different transformations after being expelled from the bodies of their mothers, and receive great augmentations of size before their metamorphosis into the nymph or chrysalis state, after which their growth stops. But the spider-fly affords an instance of an insect transformed within its mother, and which grows no more after it escapes from its envelope.

The worm, from which the tipula or crane-fly is produced, is perfectly smooth. Immediately before its first transformation it retires under ground. After this metamorphosis, the surface of the nymph is furnished with a number of spines. By means of these spines, the nymph, when about to be transformed into a fly, raises itself in its hole till the chest of the insect is above ground. The fly then bursts its prison, mounts into the air, and leaves its former covering behind in the earth.

Many species of flies deposit their eggs in the leaves and different parts of plants. Soon after the egg is inserted into the leaf, a small tubercle begins to appear, which gradually increases in magnitude till the animal is hatched, and has passed through its different transformations. These tubercles are known by the name of *galls*, and are very different in their form, texture, colour, and size. Galls of every kind, however, derive their origin from the perforators of insects, which generally belong to the class of flies. The female fly, by means of this instrument, makes incisions in the leaves or branches of a tree, and in each incision lays an egg. This egg is at first extremely minute; but it soon acquires a considerable bulk, and the gall has arrived at its full size before the worm is hatched. It is a singular and almost inexplicable fact, that the eggs of gall-flies should continue to grow after being separated from the body of the mother. But that their eggs do augment in size; that worms proceed from them; that these worms are nourished and live a certain time imprisoned in the galls; that they are there transformed into nymphs or chrysalids; and, lastly, that they are metamorphosed into winged insects, which, by gnawing an aperture through the gall, take their flight in the air; are known and incontestible facts, of the truth of which every man may easily satisfy himself. Examine the common oak-galls, or those of any other tree; if any of them happen to have no aperture, cut them gently open, and you are certain to find an egg, a worm, a chrysalis, or a fly: but in such as are perforated by a cylindrical hole, not a vestige of an animal is discoverable. The galls which make an ingredient in the composition of ink, are thick, and their texture is very strong and compact. That the small animals they contain should be able to pierce through such a rigid substance is truly wonderful.

In the general order of nature among oviparous animals, each egg includes one embryo only. A singular species of eggs, however, discoverd by the celebrated Mr Folks, late president of the Royal Society of London, must be excepted. He found great numbers of them in the mud of small rivulets. In size they equalled the head of an ordinary pin. They were of a brown colour, and their surface was crustaceous, through which, by employing the microscope, several living worms were distinctly perceptible. By dexterously breaking the shell, he dislodged them ; and he found with surprise, that eight or nine worms were contained in, and proceeded from, the same egg. They were all well formed, and moved about with great agility. Each of them was inclosed in an individual membranous covering, which was extremely thin and transparent. It were to be wished that the transformations of these extraordinary animals had been traced.

Some caterpillars, when about to transform, make a belt pass round their bodies. This belt is composed of an assemblage of silken threads spun by themselves, the ends of which they paste to the twigs of bushes, or other places where they choose to attach their bodies. They likewise fix their hind legs in a tuft of silk. After transformation, the chrysalids remain fixed in the same manner as before their metamorphosis. The belt is loose, and allows the chrysalis to perform its slow and feeble movements.

The whole moth kind, as well as the silkworm, immediately before their transformation into the chrysalis state, cover their bodies with a cod or clue of silk, though the nature of the silk, and their mode of spinning, are very different. The cods of the silkworm are composed of pure silk. Their figure is generally oval, which necessarily results from that of the animal's body upon which they are moulded. When spinning, they twist their bodies into the form of an S. The cod is produced by numberless circumvolutions and zigzags of the same thread. The silk is spun by an instrument situated near the mouth of the insect. The silky matter, before it is manufactured by the spinning instrument, appears under the form of a gum almost liquid, which is contained in two large reservoirs contorted like the intestines of larger animals, and which terminate at the extremity by two parallel and slender conduits. Each conduit furnishes matter for one thread. The spinning instrument, as is evident when viewed by the microscope, unites the two threads into one. Thus a thread of silk, which has the appearance of being single, is in reality double, and spun with great dexterity. Some writers, who delight in the marvellous, ascribe foresight to the silkworm in spinning its cod. The silkworm, it must be acknowledged, acts as if it foresaw the approaching event. But the truth is, that, when the animal has acquired its full growth, its reservoirs of silk are completely filled. It then seems to be strongly stimulated to evacuate this glutinous matter. Its different movements and attitudes, while discharging the silk, produce those oval bundles which clothe and ornament vast numbers of the human species.

Another species of caterpillar constructs its cod in the form of a boat with the keel uppermost; but it consists not entirely of pure silk. The animal, with its teeth, detaches small triangular pieces of bark from a bush or a tree. These pieces of bark it pastes upon its body by means of a glutinous or silky substance, and they constitute a principal part of its cod.

Another species works also in wood, though not with as much art as the former. Its cod is composed entirely of small irregular fragments of dried wood. These fragments the animal has the address to unite together, and to form of them a kind of box which covers and defends its whole body. It accomplishes this purpose by moistening, for some moments, the pieces of wood in its mouth, and then attaches them to each other by a glutinous substance. Of this mixture the caterpillar forms a cod, the solidity of which is nearly equal to that of wood.

The most solitary of all insects are those which live in the internal parts of fruits. Many of them undergo their metamorphosis in the fruit itself, which affords them both nourishment and a safe retreat. They dig cavities in the fruit, which some of them either line with silk, or spin cods. Others leave the fruit, and retire to be transformed in the earth.

The metamorphosis of insects has been regarded as a sudden operation, because they often burst their shell or silky covering quickly, and immediately appear furnished with wings. But, by more attentive observation, it has been discovered that the transformation of caterpillars is a gradual process from the moment the animals are hatched till they arrive at a state of perfection. Why, it may be asked, do caterpillars so frequently cast their skins? The new skin and other organs were lodged under the old ones, as in so many tubes or cases, and the animal retires from these cases, because they have become too strait. The reality of these encasements has been demonstrated by a simple experiment. When about to moult or cast its skin, if the foremost legs of a caterpillar are cut off, the animal comes out of the old skin deprived of these legs From this fact, Reaumur conjectured that the chrysalis might be thus encased. and concealed under the last skin of the caterpillar. He discovered that the chrysalis, or rather the butterfly itself, was inclosed in the body of the caterpillar. The proboscis, the antennæ, the limbs, and the wings of the fly are so nicely folded up, that they occupy a small space only under the two first rings of the caterpillar. In the first six limbs of the caterpillar are encased the six limbs of the butterfly. Even the eggs of the butterfly have been discovered in the caterpillar long before its transformation.

From these facts, it appears that the transformation of insects is only the throwing off of external and temporary coverings, and not an alteration of the original form. They live and receive nourishment in envelopes till they acquire such a degree of perfection as enables them to support the situation to which they are ultimately destined by nature.

Transformations are not peculiar to animals. All *organized bodies* pass through successive changes. Plants, of course, are not exempted from mutation. What an amazing difference between an acorn and a stately oak? The seed contains within it the rudiments of the parts of the future plant. These parts require only time and other circumstances necessary to vegetation, for their complete evolution. Beside the general changes arising from growth, plants undergo a number of metamorphoses from other causes. In northern climates, if we except a few evergreens, trees, during winter, are entirely stripped of their leaves Instead of the pleasant emotions excited by the variety of figures, movements. colours, and fragrance of the leaves, flowers, and fruit, during the spring and summer, nothing is exhibited in winter but the bare stems and branches. In this state, the trees of the forest have a lugubrious appearance, and remind us of death and of skeletons. Very different are the emotions we feel in the spring, when the buds begin to burst, and the leaves to expand. When summer approaches, another beautiful change takes place The flowers with all their splendour of colours, and sweetness of flavours, are then highly delightful to our senses After performing the office of cherishing and protecting the tender fruit for some time, the flowers drop off, and a new change is exhibited. When the flowers fall, the young fruit appears, and gradually grows to maturity, perpetually presenting varieties in its magnitude, colour, odour, and flavour. When the fruit or seeds are fully ripe, they are gathered for the use of man, drop down upon the earth, or are devoured by birds and other animals. After this change happens, to which all the others were only preparatory, the leaves begin to fall, winter commences, and the same series of metamorphoses go on during the existence of the plant.

The changes just now mentioned are annual, and are ultimately intended to supply men and other animals with food. But plants are subjected to changes of form from causes of a more accidental nature. Varieties or changes in the figure of plants are often produced by soil, by situation, by culture, and by climate

The petals of all flowers, in a natural state, are single But, when transplanted into gardens, many of them, especially those which are furnished with numerous stamina, as the anemone, the poppy, the peony, the ranunculus, the daisy, the marigold, the rose, &c. double, or rather multiply their flower leaves without end. This change from single to double, or monstrous flowers, as they are called, is produced by too great a quantity of nutritious juices, which transforms the stamina into petals; and it not unfrequently happens, that, when these double-flowering plants are committed to a poor soil, they become drier, are reduced to their natural state, and produce single flowers only. Plants which inhabit the valleys, when transported to the tops of mountains, or other elevated situations, not only become dwarfish, but undergo such changes in their general structure and appearance, that they are often thought to belong to a different species, though they are, in reality, only varieties of the same. Similar changes are produced when Alpine or mountain plants are cultivated in the valleys.

From culture and climate, likewise, plants undergo many changes. But this subject is so generally known, that to enlarge upon it would be entirely superfluous. We shall only remark, that the older botanists, when they perceived the same species of plants growing in a different soil, or in a different climate, assume such different appearances, considered and enumerated them as distinct species. But the modern botanists, to prevent the unnecessary multiplication of separate beings, have endeavoured to reduce all those varieties arising from fortuitous circumstances to their original species.

From these facts, and many others which might be mentioned, it appears, that, in both the animal and vegetable kingdoms, forms are perpetually changing. The mineral kingdom is not less subject to metamorphosis; but this belongs not to our present subject. Though forms continually change, the quantity of matter is invariable. The same substances pass successively into the three kingdoms, and constitute, in their turn, a mineral, a plant, an insect, a reptile, a fish, a bird, a quadruped, a man. In these transformations, organized bodies are the principal agents. They change or decompose every substance that either enters into them, or is exposed to the action of their powers. Some they assimilate, by the process of nutrition, into their own substance; others they evacuate in different forms; and these evacuations make ingredients in the compositions of other bodies, as those of insects, whose multiplication is prodigious, and affords a very great quantity of organized matter for the nourishment and support of almost every animated being. Thus, from the apparently vilest and most contemptible species of matter, the richest productions derive their origin. The most beautiful flowers, the most exquisite fruits, and the most useful grain, all proceed from the bosom of corruption. The earth is continually bestowing fresh gifts upon us; and her powers would soon be exhausted, if what she perpetually gives were not perpetually restored to her. It is a law of nature, that all organized bodies should be decomposed, and gradually transformed into earth. While undergoing this species of dissolution, their more volatile particles pass into the air, and are diffused through the atmosphere. Thus animals, at least portions of them, are buried in the air, as well as in the earth, or in water. These floating particles soon enter into the composition of new organized beings, which are themselves destined to undergo the same revolutions. This circulation of organized matter has continued since the commencement of the world, and will proceed in the same course till its final destruction.

With regard to the intentions of Nature in changing forms, a complete investigation of them exceeds the powers of human research. One great intention, from the examples above enumerated, cannot escape observation. In the animal world, every successive change is a new approach to the perfection of the individuals. Men, and the larger animals, some time after the age of puberty, remain stationary, and continue to multiply their species for periods proportioned to their respective species. When those periods terminate, they gradually decay till their final dissolution. The same observation is applicable to the insect tribes whose transformations strike us with wonder. The caterpillar repeatedly moults or casts off its skin. The butterfly existed originally in the body of the caterpillar; but the organs of the fly were too soft, and not sufficiently unfolded. It remains unfit to encounter the open air, or to perform the functions of a perfect animal, till some time after its transformation into a chrysalis. It then bursts through its envelope, arrives at a state of perfection, multiplies its species, and dies. All the changes in the vegetable kingdom tend to the same point. In the process of growing, they are perpetually changing forms till they produce fruit, and then they decay. Some plants, like caterpillars, go through all their transformations, death not excepted, in one year. But others, like man and the larger animals, beside the common changes produced by growth and the evolution of different organs, continue for many years in a state of perfection before the periods of decay and of dissolution arrive. But these perennial plants undergo, every year, all the vicissitudes of the annual. They every year increase in magnitude, send forth new leaves and branches, ripen and disseminate their seeds, and, during winter, remain in a torpid state, or suffer a temporary death. These annual changes in trees, &c. have some resemblance to those of animals, which produce at certain stated seasons only.

The distribution of life to an immensity of successive individuals seems to be another intention of Nature in changing forms, and in the dissolution of her productions. Were the existence of individuals perpetual, or were it prolonged for ten times the periods now established, life would be denied to myriads of animated beings, which enjoy their present limited portion of happiness.

CHAPTER VIII.

OF THE HABITATIONS OF ANIMALS.

MANY animals, beside those of the human species, have the faculty of constructing proper habitations for concealing themselves, for defending themselves against the attacks of their enemies, for sheltering and cherishing their young, and for protecting them from the injuries of the weather. All those of the same species, when not restrained by accidental causes, uniformly build in the same style, and use the same materials. From this general rule man is to be excepted. Possessed of superior faculties and understanding, he can build in any style, and employ such materials as his taste, his fancy, or the purposes for which the fabric is intended, shall direct him. A cottage and a palace are equally within the reach of his powers. In treating of this subject, we mean not to trace the progress of human architecture, which, in the earlier stages of society, is extremely rude, but to confine ourselves to that of the inferior tribes of animated beings

With regard to Quadrupeds, many of them employ no kind of architecture, but live continually, and bring forth their young, in the open air. When not under the immediate protection of man, these species, in rough or stormy weather, shelter themselves among trees or bushes, retire under the coverture of projecting rocks, or the sides of hills opposite to those from which the wind proceeds Beside these arts of defence, to which they are prompted by instinct and experience, nature furnishes them, during the winter months, with a double portion of long hair, which protects them from cold, and other assaults of the weather.

Of the quadrupeds that make or choose habitations for themselves, some dig holes in the earth, some take refuge in the cavities of decayed trees, and in the clefts of rocks, and some actually construct cabins, or houses. But the artifices they employ, the materials they use, and the situations they select, are so various and so numerous, that our plan necessarily limits us to a few of the more curious examples.

The Alpine Marmot is a quadruped about sixteen inches in length, and has a short tail. In figure, the marmots have some resemblance both to the rat and to the bear. When tamed, they eat every thing presented to them, as flesh, bread, fruit, roots, pot-herbs, insects, &c They delight in the regions of frost and of snow, and are only to be found on the tops of the highest mountains. These animals remain in a torpid state during winter. About the end of September, or the beginning of October, they retire into their holes, and never come abroad again till the beginning of April. Their retreats are formed with much art and precaution. With their feet and claws, which are admirably adapted to the purpose, they dig the earth with amazing quickness, and throw it behind them. They do not make a simple hole, or a straight or winding tube, but a kind of gallery in the form of a Y, each branch of which has an aperture, and both terminate in a capacious apartment. As the whole operation is performed on the declivity of a mountain, this innermost apartment alone is horizontal. Both branches of the Y are inclined One of the branches descends under the apartment, and follows the declivity of the mountain This branch is a kind of aqueduct, and receives and carries off the filth of their habitations; and the other, which rises above the principal apartment, is used for coming in and going out. The place of their abode is well lined with moss and hay, of which they lay up great store during the summer. They are social animals. Several of them live together, and work in common when forming their habitations. Thither they retire during rain, or upon the approach of danger. One of them stands centinel upon a rock, while the others gambol upon the grass, or are employed in cutting it, in order to make hay. If the centinel perceives a man, an eagle, a dog, or other dangerous animal, he alarms his companions by a loud whistle, and is himself the last that enters the hole. They continue torpid during winter, and, as if they foresaw that they would then have no occasion for victuals, they lay up no provisions in their apartments. But, when they feel the first approaches of the sleeping season, they shut up both passages to their habitation; and this operation they perform with such labor and solidity, that it is more easy to dig the earth any where else, than in such parts as they have thus fortified. At this time they are very fat, weighing sometimes twenty pounds. They continue to be plump for three months; but afterwards they gradually decline, and, at the end of winter, they are extremely emaciated. When seized in their retreats, they appear rolled up in the form of a ball, and covered with hay. In this state, they are so torpid that they may be killed without seeming to feel pain. The hunters select the fattest for eating, and keep the young ones for taming. Like the dormice, and all the other animals which sleep during winter, the marmots are revived by a gradual and gentle heat; and it is remarkable, that those which are fed in houses, and kept warm, never become torpid, but are equally active and lively during the whole year.

The Beaver is about three feet in length, and its tail, which is of an oval figure, and covered with scales, is eleven inches long. He uses his tail as a rudder to direct his course in the water. In places much frequented by man, the beavers neither associate nor build habitations. But in the northern regions of both continents, they assemble in the month of June or July, for the purposes of uniting into society and of building a city. From all quarters they arrive in numbers, and soon form a troop of two or three hundred. The operations and architecture of the beavers are so well described by the Count de Buffon, that we shall lay it before our readers nearly in his own words. The place of rendezvous, he remarks, is generally the situation fixed upon for their establishment, and it is always on the banks of waters. If the waters be flat, and seldom rise above their ordinary level, as in lakes, the beavers make no bank or dam. But in rivers or brooks, where the water is subject to risings and fallings, they build a bank, which traverses the river from one side to the other, like a sluice, and is often from eighty to a hundred feet long, by ten or twelve broad at the base. This pile, for animals of so small a size, (the largest beavers weighing only fifty or sixty pounds) appears to be enormous, and presupposes an incredible labour. But the solidity with which the work is constructed is still more astonishing than its magnitude. The part of the river where they erect this bank is generally shallow. If they find on the margin a large tree, which can be made to fall into the river, they begin, by cutting it down, to form the principal basis of their work. This tree is often thicker than a man's body. By gnawing it at the bottom with their four cutting teeth, they in a short time accomplish their purpose, and always make the tree fall across the river. They next cut the branches from the trunk to make it lie level. These operations are performed by the joint industry of the whole community. Some of them, at the same time, traverse the banks of the river, and cut down smaller trees, from the size of a man's leg to that of his thigh. These they cut to a certain length, dress them into stakes, and first drag them by land to the margin of the river, and then by water to the place where the building is carrying on. These piles they sink down, and interweave the branches with the larger stakes In performing this operation many difficulties are to be surmounted. In order to dress these stakes, and to put them in a situation nearly perpendicular, some of the beavers must elevate, with their teeth, the thick ends against the margin of the river, or against the cross tree, while others plunge to the bottom, and dig holes with their forefeet to receive the points, that they may stand on end. When some are labouring in this manner, others bring earth in their mouths and with their forefeet, and transport it in such quantities, that they fill with it all the intervals between the piles. These piles consist of several rows of stakes of equal height, all placed opposite to each other, and extend from one bank of the river to the other. The stakes facing the lower part of the river are placed perpendicularly; but those which are opposed to the stream slope upward to sustain the pressure of the water; so that the bank, which is ten or twelve feet wide at the base, is reduced to two or three at the top. Near the top, or thinnest part of the bank, the beavers make two or three sloping holes, to allow the surface-water to escape. These they enlarge or contract in proportion as the river rises or falls; and, when any breaches are made in the bank by sudden or violent inundations, they know how to repair them when the water subsides.

Hitherto all these operations were performed by the united force and dexterity of the whole community. They now separate into smaller societies, which build cabins or houses. These cabins are constructed upon piles near the margin of the river or pond, and have two openings, one for the animals going to the land, and the other for throwing themselves into the water. The form of these edifices is either round or oval, and they vary in size from four or five to eight or ten feet in diameter. Some of them consist of three or four stories. Their walls are about two feet thick; and are raised perpendicularly upon planks, or plain stakes, which serve both for foundations and floors to their houses. When they consist of but one story, they rise perpendicularly a few feet only, afterwards assume a curved form, and terminate in a dome or vault, which answers the purpose of a roof. They are built with amazing solidity, and neatly plastered with a kind of stucco both within and without. In the application of this mortar the tails of the beavers serve for trowels, and their feet for plashing. Their houses are impenetrable to rain, and resist the most impetuous winds. In their construction, they employ different materials, as wood, stone, and a kind of sandy earth, which is not liable to be dissolved in water. The wood they use is generally of the light and tender kinds, as alders, poplars, and willows, which commonly grow on the banks of rivers, and are more easily barked, cut, and transported, than the heavier and more solid species of timber. They always begin the operation of cutting trees at a foot or a foot and a half above the ground. They labour in a sitting posture; and, beside the convenience of this posture, they enjoy the pleasure of gnawing perpetually the bark and wood, which are their favourite food. Of these provisons they lay up ample stores in their cabins to support them during the winter. Each cabin has its own magazine, which is proportioned to the number of its inhabitants, who have all a common right to the store, and never pillage their neighbours. Some villages are composed of twenty or twenty-five cabins. But these large establishments are not frequent; and the common republics seldom exceed ten or twelve families, which each have their own quarter of the village, their own magazine, and their separate habitation. The smallest cabins contain two, four, or six, and the largest eighteen, twenty, and sometimes thirty beavers. As to males and females, they are almost always equally paired. Upon a moderate computation, therefore, the society is often composed of a hundred and fifty or two hundred, who all, at first, labour jointly in raising the great public building, and afterwards, in select tribes or companies, in making particular habitations. In this society, however numerous, an universal peace is maintained. Their union is cemented by common labours; and it is perpetuated by mutual conveniency, and the abundance of provisions which they amass and consume together. A simple taste, moderate appetites, and an aversion to blood and carnage, render them destitute of the ideas of rapine and of war. Friends to each other, if they have any foreign enemies they know how to avoid them. When danger approaches, they advertise one another, by striking their broad tail on the surface of the water, the noise of which is heard at a great distance, and resounds through all the vaults of their habitations. Each individual, upon these occasions, consults his own safety; some plunge into the water; others conceal themselves within their walls, which can be penetrated only by the fire of heaven, or the steel of man, and which no animal will attempt either to open or to overturn. These retreats are not only safe, but neat and commodious. The floors are spread over with verdure; the branches of the box and of the fir serve them for carpets, upon which they permit not the smallest dirtiness. The window that faces the water answers for a balcony to receive the fresh air, and for the purpose of bathing. During the greater part of the day, the beavers sit on end, with their head and the anterior parts of their body elevated, and their posterior parts sunk in the water. The aperture of this window is sufficiently raised to prevent its being stopped up with the ice, which, in the beaver climates, is often two or three feet thick. When this accident happens, they slope the sole of the window, cut obliquely the stakes which support it, and thus open a communication with the unfrozen water. They often swim a long way under the ice. In September, the beavers collect their provisions of bark and of wood. Till the end of winter, they remain in their cabins, enjoy the fruits of their labours, and taste the sweets of domestic happiness. This is their time of repose. In the spring they separate; the males retire into the country to enjoy the pleasures and fruits of spring. They return occasionally, however, to their cabins; but dwell there no more. The females continue in the cabins, and are occupied in nursing, protecting, and rearing their young, which in a few weeks are in a condition to follow their dams. The beavers assemble not again till autumn, unless their banks or cabins be injured by inundations; for, when accidents of this kind happen, they suddenly collect their forces, and repair the breaches that have been made.

This account of the society and operations of beavers, however marvellous it may appear, has been established and confirmed by so many credible eyewitnesses, that it is impossible to doubt of its reality.

The habitation where Moles deposit their young merits a particular description; because it is constructed with peculiar intelligence, and because the mole is an animal with which we are well acquainted. They begin by raising the earth, and forming a pretty high arch. They leave partitions, or a kind of pillars, at certain distances, beat and press the earth, interweave it with the roots of plants, and render it so hard and solid, that the water cannot penetrate the vault, on account of its convexity and firmness. They then elevate a little hillock under the principal arch; upon the latter they lay herbs and leaves for a bed to their young. In this situation they are above the level of the ground, and of course, beyond the reach of ordinary inundations. They are, at the same time, defended from the rains by the large vault that covers the internal one, upon the convexity of which last they rest along with their young. This internal hillock is pierced on all sides with sloping holes, which descend still lower, and serve as subterraneous passages for the mother to go in quest of food for herself and her offspring. These by-paths are beaten and firm, extend about twelve or fifteen paces, and issue from the principal mansion like rays from a centre. Under the superior vault we likewise find remains of the roots of the meadow saffron, which seem to be the first food given to the young. From this description it appears, that the mole never comes abroad but at considerable distances from her habitation. Moles, like the beavers, pair; and so lively and reciprocal an attachment subsists between them, that they seem to disrelish all other society. In their dark abodes they enjoy the placid habits of repose and of solitude, the art of securing themselves from injury, of almost instantaneously making an asylum or habitation, and of procuring a plentiful subsistence without the necessity of going abroad. They shut up the entrance of their retreats, and seldom leave them, unless compelled by the admission of water, or when their mansions are demolished by art.

The nidification of Birds has at all times called forth the admiration of mankind. In general, the nests of birds are built with an art so exquisite, that an exact imitation of them exceeds all the powers of human skill and industry. Their style of architecture, the materials they employ, and the situations they select, are as various as the different species. Individuals of the same species, whatever region of the globe they inhabit, collect the same materials, arrange and construct them in the same form, and make choice of similar situations for erecting their temporary habitations; for the nests of birds, those of the eagle kind excepted, after the young have come to maturity, are forever abandoned by the parents.

To describe minutely the nests of birds would be a vain attempt. Such descriptions could not convey an adequate idea of their architecture to a person who had never seen one of those beautiful and commodious habitations, which even astonish, and excite the amazement of children.

The different orders of birds exhibit great variety in the materials and structure of their nests. Those of the rapacious tribes are in general rude, and composed of coarse materials, as dried twigs, bents, &c. But they are often lined with soft substances. They build in elevated rocks, ruinous and sequestered castles and towers, and in other solitary retirements. The aerie or nest of the eagle is quite flat, and not hollow, like those of other birds. The male and female commonly place their nest between two rocks, in a dry and inaccessible situation. The same nest, it is said, serves the eagle during life. The structure is so considerable, and composed of such solid materials, that it may last many years. Its form resembles that of a floor. Its basis consists of sticks about five or six feet in length, which are supported at each end, and these are covered with several layers of rushes and heath. An eagle's nest was found in the Peak of Derbyshire, which Willoughby describes in the following manner: "It was made of great sticks, resting one end on the edge of a rock, the other on a birch tree. Upon these was a layer of rushes, and over them a layer of heath, and upon the heath rushes again; upon which lay one young, and an addle egg; and by them a lamb, a hare, and three heathpouts. The nest was about two yards square, and had no hollow in it." But the butcher-birds, or shrikes, which are less rapacious than eagles and hawks, build their habitations in shrubs and bushes, and employ moss, wool, and other soft materials.

The common magpies build their nests in trees, and their structure is admirably contrived for affording warmth and protection to the young. The nest is not open at top: It is covered, in the most dexterous manner, with an arch or dome, and a small opening in the side of it is left, to give the parents an opportunity of passing in and out at their pleasure. To protect their eggs and young from the attacks of other animals, the magpies place, all round the external surface of their nest, sharp briars and thorns. The long-tailed titmouse, or ox-eye, builds nearly like the wren, but with still greater art. With the same materials as the rest of the structure, the titmouse builds an arch over the top of the nest, which resembles an egg erected upon one end, and leaves a small hole in the side for a passage. Both eggs and young, by this contrivance, are defended from the injuries of the air, rain, cold, &c. That the young may have a soft and warm bed, she lines the inside of the nest with feathers, down, and cobwebs. The sides and roof are composed of moss and wool interwoven in the most curious and artificial manner.

Mr Pennant, in his Indian Zoology, gives the following curious account of the manner in which the Motacilla sutoria, or tailor-bird, builds its nest. "Had providence," Mr Pennant remarks, "left the feathered tribes unendowed with any particular instinct, the birds of the torrid zone would have built their nests in the same unguarded manner as those of Europe; but there the lesser species, having a certain prescience of the dangers that surround them, and of their own weakness, suspend their nests at the extreme branches of the trees. They are conscious of inhabiting a climate replete with enemies to them and their young; with snakes that twine up the bodies of the trees, and apes that are perpetually in search of prey; but, heaven-instructed, they elude the gliding of the one, and the activity of the other.—The brute creation are more at enmity with one another than in other climates; and the birds are obliged to exert an unusual artifice in placing their little broods out of the reach of an invader. Each aims at the same end, though by different means; some form their pensile nest in shape of a purse, deep and open at top; others, with a hole in the side; and others, still more cautious, with an entrance at the very bottom, forming their lodge near the summit.* But the tailor-bird seems to have greater diffidence than any of the others; it will not trust its nest even to the extremity of a slender twig, but makes one more advance to safety by fixing it to the leaf itself. It picks up a dead leaf, and, surprising to relate, sews it to the side of a living one, its slender bill being its needle, and its thread some fine fibres, the lining feathers, gossamer, and down. Its eggs are white, the colour of the bird light yellow; its length three inches; its weight only three sixteenths of an ounce; so that the materials of the nest, and its own size, are not likely to draw down a habitation that depends on so slight a tenure."

Birds of the gallinaceous or poultry kind lay their eggs on the ground. Some of them scrape a kind of hole in the earth, and line it with a little long grass or straw.

It is a singular, though a well attested fact, that the cuckoo makes no nest, and neither hatches nor feeds her own young.

* This instinct prevails also among the birds on the banks of the Gambia, in Africa, which abounds with monkeys and snakes; others, for the same end, make their nest in holes of the banks that over hang that vast river. Purchas, vol. 2. p. 1576.

"The hedge-sparrow," says Mr Willoughby, "is the cuckoo's nurse, but not the hedge-sparrow only, but also ring-doves, larks, finches. I myself, with many others, have seen a wag-tail feeding a young cuckoo. The cuckoo herself builds no nest; but having found the nest of some little bird, she either devours or destroys the eggs she there finds, and, in the room thereof, lays one of her own, and so forsakes it. The silly bird returning, sits on this egg, hatches it, and, with a great deal of care and toil, broods, feeds, and cherishes the young cuckoo for her own, until it be grown up, and able to fly and shift for itself. Which thing seems so strange, monstrous, and absurd, that for my part I cannot sufficiently wonder there should be such an example in nature; nor could I ever have been induced to believe that such a thing had been done by nature's instinct, had I not with mine own eyes seen it. For nature, in other things, is wont constantly to observe one and the same law and order, agreeable to the highest reason and prudence; which in this case is, that the dams make nests for themselves, if need be, sit upon their own eggs, and bring up their own young after they are hatched."* This economy, in the history of the cuckoo, is not only singular, but seems to contradict one of the most universal laws established among animated beings, and particularly among the feathered tribes, namely, the hatching and rearing of their offspring. Still, however, like the ostrich in very warm climates, though the cuckoo neither hatches nor feeds her young, she places her eggs in situations where they are both hatched and her offspring brought to maturity. Here the stupidity of the one animal makes it a dupe to the rapine and chicane of the other; for the cuckoo always destroys the eggs of the small bird before she deposits her own.

Most of the passerine or small birds build their nests in hedges, shrubs, or bushes; though some of them, as the lark and the goat-sucker, build upon the ground. The nests of small birds are more delicate in their structure and contrivance than those of the larger kinds. As the size of their bodies, and likewise that of their eggs, are smaller, the materials of which their nests are composed are generally warmer. Small bodies retain heat a shorter time than those which are large. Hence, the eggs of small birds require a more constant supply of heat than those of greater dimensions. Their

* Willoughby's Ornithology, p. 98.

nests, accordingly, are built proportionally warmer and deeper, and they are lined with softer substances. The larger birds, of course, can leave their eggs for some time with impunity; but the smaller kinds sit most assiduously; for, when the female is obliged to go abroad in quest of food, the nest is always occupied by the male. When a nest is finished, nothing can exceed the dexterity of both male and female in concealing it from the observation of man, and of other destructive animals. If it is built in bushes, the pliant branches are disposed in such a manner as to hide it entirely from view. To conceal her retreat, the chaffinch covers the outside of her nest with moss, which is commonly of the same colour with the bark of the tree on which she builds. The common swallow builds its nests on the tops of chimneys; and the martin attaches hers to the corners of windows, or under the eaves of houses. Both employ the same materials. The nest is built with mud well tempered by the bill, and moistened with water to make it more firmly cohere; and the mud or clay is kept still firmer by a mixture of straw or grass. Within, it is neatly lined with feathers. Willoughby, on the authority of Bontius, informs us, "That on the sea-coast of the kingdom of China, a sort of small party-coloured birds, of the shape of swallows, at a certain season of the year, viz. their breeding time, come out of the midland country to the rocks; and from the foam or froth of the sea-water dashing and breaking against the bottom of the rocks, gather a certain clammy, glutinous matter, perchance the sperm of whales, or other fishes, of which they build their nests, wherein they lay their eggs, and hatch their young. These nests the Chinese pluck from the rocks, and bring them in great numbers into the East Indies to sell; which are esteemed by gluttons great delicacies, who, dissolving them in chicken or mutton broth, are very fond of them, preferring them far before oysters, mushrooms, or other dainty and lickerish morsels which most gratify the palate.—These nests are of a hemispherical figure, of the bigness of a goose-egg, and of a substance resembling isinglass."

Most of the cloven-footed water-fowls, or waders, lay their eggs upon the ground. But, the spoon-bills and the common heron build large nests in trees, and employ twigs and other coarse materials; and the storks build on churches, or on the tops of houses. Many of the web-footed fowls lay their eggs likewise on the ground, as the terns, and some of the gulls and mergansers. But ducks pull the down from their own breasts to afford a warmer and more comfortable bed for their young. The awks, the guillemots, and the puffins or coulternebs, lay their eggs on the naked shelves of high rocks. The penguins, for the same purpose, dig large and deep holes under ground.

It is not unworthy of remark, that birds uniformly proportion the dimensions of their nests to the number and size of the young to be produced. Every species lays nearly a determined number of eggs. But, if one be each day abstracted from the nest, the bird continues to lay daily more till her number is completed. Dr Lister, by this practice, made a swallow lay no less than nineteen eggs.

The habitations of Insects are next to be considered. On this branch of the subject, we shall first give some examples of abodes constructed by solitary workers, and next of those habitations which are executed by associated numbers.

In several preceding parts of this work, the reader will find some instances of the skill and industry exhibited by insects, for the convenient lodging and protection of their young. These it is unnecessary to repeat. We shall therefore proceed to give some examples of a different kind.

There are several species of bees distinguished by the appellation of *solitary*, because they do not associate to carry on any joint operations. Of this kind is the *mason-bee*, so called because it builds a habitation composed of sand and mortar. The nests of this bee are fixed to the walls of houses, and, when finished, have the appearance of irregular prominences arising from dirt or clay accidentally thrown against a wall or stone by the feet of horses. These prominences are not so remarkable as to attract attention; but, when the external coat is removed, their structure is discovered to be truly admirable. The interior part consists of an assemblage of different cells, each of which affords a convenient lodgment to a white worm, pretty similar to those produced by the honey-bee. Here they remain till they have undergone all their metamorphoses. In constructing this nest, which is a work of great labour and dexterity, the female is the sole operator. She receives no assistance from the male. The manner in which the female mason-bees build their nests, is the most curious branch of their history.

After choosing a part of a wall on which she is resolved to fix an habitation for her future progeny, she goes in quest of proper materials. The nest to be constructed must consist of a species of mortar, of which sand is the basis. She knows, like human builders, that every kind of sand is not equally proper for making good mortar. She goes, therefore, to a bed of sand, and selects, grain by grain, the kind which is best to answer her purpose. With her teeth, which are as large and as strong as those of the honey-bee, she examines and brings together several grains. But sand alone will not make mortar. Recourse must be had to a cement similar to the slacked lime employed by masons. Our bee is unacquainted with lime, but she possesses an equivalent in her own body. From her mouth she throws out a viscid liquor, with which she moistens the first grain pitched upon. To this grain she cements a second, which she moistens in the same manner, and to the former two she attaches a third, and so on, till she has formed a mass as large as the shot usually employed to kill hares. This mass she carries off in her teeth to the place she had chosen for erecting her nest, and makes it the foundation of the first cell. In this manner she labours incessantly till the whole cells are completed, a work which is generally accomplished in five or six days. All the cells are similar, and nearly equal in dimensions. Before they are covered, their figure resembles that of a thimble. She never begins to make a second till the first be finished. Each cell is about an inch high, and nearly half an inch in diameter. But the labour of building is not the only one this female bee has to undergo. When a cell has been raised to one half or two thirds of its height, another occupation commences. She seems to know the quantity of food that will be necessary to nourish the young that is to proceed from the egg, from its exclusion till it acquires its full growth and passes into the chrysalis state. The food which is prepared for the support of the young worm consists of the farina or powder of flowers, diluted with honey, which forms a kind of pap. Before the cell is entirely finished, the mason-bee collects from the flowers, and deposits in the cell, a large quantity of farina, and afterwards disgorges upon it as much honey as dilutes it, and forms it into a kind of paste, or syrup. When this operation is performed, she completes her cell, and after depositing an egg in it covers the mouth of it with the same mortar she uses in building her nest. The egg is now inclosed on all sides in a walled habitation hermetically sealed. A small quantity of air, however, gets admission to the worm, otherwise it could not exist. Reaumur discovered that air actually penetrated through this seemingly compact mason-work.

As soon as the first cell is completed, the mason-bee lays the foundation of another. In the same nest she often constructs seven or eight cells, and sometimes only three or four. She places them near each other, but not in any regular order. This industrious animal, after all her cells are constructed, filled with provisions, and sealed, covers the whole with an envelope of the same mortar, which, when dry, is as hard as stone. The nest now is commonly of an oblong or roundish figure, and the external cover is composed of coarser sand than that of the cells. As the nests are almost as durable as the walls on which they are placed, they are often, in the following season, occupied and repaired by a stranger bee. Though inclosed with two hard walls, when the fly emerges from the chrysalis state, it first gnaws with its teeth a passage through the wall that sealed up the mouth of its cell; afterwards, with the same instruments, it pierces the still stronger and more compact cover which invests the whole nest; at last it escapes into the open air, and, if a female, in a short time, constructs a nest of the same kind with that which the mother had made. To all these facts, Du Hamel, Reaumur, and many other naturalists of credit and reputation, have been repeatedly eye-witnesses.

From the hardness of the materials with which the mason-bee constructs her nest, from the industry and dexterity she employs to protect her progeny from enemies of every kind, one would naturally imagine that the young worms were in perfect safety, and that their castle was impregnable. But, notwithstanding all these favourable precautions, the young of the mason-bee are often devoured by the instinctive dexterity of certain species of four-winged insects, distinguished by the name of ichneumon-flies These flies, when the mason-bee has nearly completed a cell, and filled it with provisions, deposit their own eggs in her cell. After the eggs of the ichneumon-flies are hatched, their worms devour not only the provisions laid up by the mason-bee, but even her progeny whom she had laboured so hard, and with so much art and ingenuity, to protect. But the mason-bee has an enemy still more formidable. A certain fly employs the same stratagem of insinuating an egg into one of her cells before it is completed. From this egg proceeds a strong and rapacious worm, armed with prodigious fangs. The devastations of this worm are not confined to one cell. It often pierces through each cell in the nest, and successively devours both the mason-worms, and the provisions so anxiously laid up for their support by the mother. This stranger worm is afterwards transformed into a fine beetle, who is enabled to pierce the nest, and to make his escape.

The operations of another species of solitary bees, called wood-piercers merit attention. These bees are larger than the queens of the honey-bee. Their bodies are smooth, except the sides, which are covered with hair. In the spring, they frequent gardens, and search for rotten, or at least dead wood, in order to make a habitation for their young. When a female of this species,—for she receives no assistance from the male,—has selected a piece of wood, or a decayed tree, she commences her labour by making a hole in it, which is generally directed toward the axis of the tree. When she has advanced about half an inch, she alters the direction of the hole, and conducts it nearly parallel to the axis of the wood. The size of her body requires that this hole should have a considerable diameter. It is often so large as to admit the finger of a man, and it sometimes extends from twelve to fifteen inches in length. If the thickness of the wood permits, she makes three or four of these long holes in its interior part. M. de Reaumur found three of these parallel holes in an old espalier post. Their diameters exceeded half an inch. This labour, for a single bee, is prodigious; but, in executing it, she consumes weeks, and even months.

Around the foot of a post or piece of wood where one of these bees is working, little heaps of timber-dust are always found lying on the ground. These heaps daily increase in magnitude, and the particles of dust are as large as those produced by a hand-saw. The two teeth with which the animal is provided are the only instruments she employs in making such considerable perforations. Each tooth consists of a solid piece of shell, which in shape resembles an auger. It is convex above, concave below, and terminates in a sharp but strong point.

These long holes are designed for lodgings to the worms that are to proceed from the eggs which the bee is soon to deposit in them. But, after the holes are finished, her labour is by no means at an end. The eggs must not be mingled, or piled above each other. Every separate worm must have a distinct apartment, without any communication with the others.

Each long hole or tube, accordingly, is only the outer walls of a house which is to consist of many chambers ranged one above another. A hole of about twelve inches in length she divides into ten or twelve separate apartments, each of which is about an inch high. The roof of the lowest room is the floor of the second, and so on to the uppermost. Each floor is of about the thickness of a French crown. The floors or divisions are composed of particles of wood cemented together by a glutinous substance from the animal's mouth. In making a floor, she commences with gluing an annular plate of wood-dust round the internal circumference of the cavity. To this plate she attaches a second, to the second a third, and to the third a fourth, till the whole floor is completed. The undermost cell requires only a roof, and this roof is a floor to the second, &c.

But these operations, though great, and seemingly superior to the powers of a creature so small, are not her only labour. Before roofing in the first cell, she fills it with a paste or pap, composed of the farina of flowers moistened with honey. The quantity of paste is equal to the dimensions of the cell, which is about an inch high, and half an inch in diameter. In this paste, which is to nourish the future worm, she deposits an egg. Immediately after this operation, she begins to form a roof, which not only incloses the first cell, but serves as a floor to the second. The second cell she likewise fills with paste, deposits an egg, and then covers the whole with another roof. In this manner she proceeds, till she has divided the whole tube into separate cells. A single tube frequently contains from ten to a dozen of these cells. When the cells are all inclosed, the business of this laborious bee is finished, and she takes no more charge of her future progeny. The attention and solicitude bestowed by many other animals, in rearing their young, are exerted after birth. But, in the wood-piercing bee, as well as in many other insects, this instinctive attachment is reversed. All her labours and all her cares are exerted before she either sees her offspring, or knows that they are to exist. But, after the description that has been given of her amazing operations, she will not be considered as an unnatural mother. With astonishing industry and perseverance, she not only furnishes her young with safe and convenient lodgings, but lays up for them stores of provisions sufficient to support them till their final metamorphosis into flies, when the new females perform the same almost incredible operations for the protection and sustenance of their own offspring. When the young worm is hatched, it has scarcely sufficient space to turn itself in the cell, which is almost entirely filled with the pappy substance formerly mentioned. But, as this substance is gradually devoured by the worm, the space in the cell necessarily enlarges in proportion to the growth and magnitude of the animal.

We are informed by M. de Reaumur, that M. Pitot furnished him with a piece of wood, not exceeding an inch and a half in diameter, which contained the cells of a wood-piercing bee. He cut off as much of the wood as was sufficient to expose two of the cells to view, in each of which was a worm. The aperture he had made, to prevent the injuries of the air, he closed, by pasting on a bit of glass. The cells were then almost entirely filled with paste. The two worms were exceedingly small, and, of course, occupied but little space between the walls of the cells and the mass of paste. As the animals increased in size, the paste daily diminished. He began to observe them on the 12th day of June; and, on the 27th of the same month, the paste in each cell was nearly consumed, and the worm, folded in two, occupied the greater part of its habitation. On the 2d of July, the provisions of both worms were entirely exhausted; and, beside the worms themselves, there remained in the cells only a few small, black, oblong grains of excrement. The five or six following days they fasted, which seemed to be a necessary abstinence, during which they were greatly agitated. They often bended their bodies, and elevated and depressed their heads. These movements were preparatory to the great change the animals were about to undergo. Between the 7th and 8th of the same month, they threw off their skins, and were metamorphosed into nymphs. On the 30th of July, these nymphs were transformed into flies similar to their parents. In a range of cells, the worms are of different ages, and, of course, of different sizes. Those in the lower cells are older than those in the superior; because, after the bee has filled with paste and inclosed its first cell, a considerable time is requisite to collect provisions, and to form partitions for every successive and superior cell. The former, therefore, must be transformed into nymphs and flies before the latter. These circumstances are apparently foreseen by the common mother; for, if the undermost worm, which is oldest, and soonest transformed, were to force its way upward, which it could easily do, it would not only disturb, but infallibly destroy, all those lodged in the superior cells. But Nature has wisely prevented this devastation; for the head of the nymph, and consequently of the fly, is always placed in a downward direction. Its first instinctive movements must, therefore, be in the same direction. That the young flies may escape from their respective cells, the mother digs a hole at the bottom of the long tube, which makes a communication with the undermost cell and the open air. Sometimes a similar passage is made near the middle of the tube. By this contrivance, as all the flies instinctively endeavour to cut their way downward, they find an easy and convenient passage; for they have only to pierce the floor of their cells, which they readily perform with their teeth.

Another small species of solitary bees dig holes in the earth to make a convenient habitation for their young. Their nests are composed of cylindrical cells fixed to one another, and each of them, in figure, resembles a thimble. Their bottom, of course, is convex and rounded. The bottom of the second is inserted into the entry of the first; and the entry of the second receives the bottom of the third. They are not all of the same length. Some of them are five lines long, others only four, and their diameters seldom exceed two lines. Sometimes only two of these cells are joined together; and, at other times, we find three or four, which form a kind of cylinder. This cylinder is composed of alternate bands of two different colours; those of the narrowest, at the juncture of two cells, are white, and those of the broadest are of a reddish brown. The cells consist of a number of fine membranes, formed of a glutinous and transparent substance from the animal's mouth. Each cell our bee fills with the farina of flowers diluted with honey, and in this paste she deposits an egg. She then covers the cell, by gluing to its mouth a fine cellular substance taken from the leaves of some plant; and in this manner she proceeds till her cylindrical nest is completed. The worms which are hatched from the eggs feed upon the paste, so carefully laid up for them by the mother, till they are transformed into flies similar to their parents.

Among wasps, as well as bees, there are solitary species, which carry on no joint operations. These solitary wasps are not less ingenious in constructing proper habitations for their young, nor less provident in laying up for them a store of nourishment sufficient to support them till they are transformed into flies, or have become perfect animals. But, to give a detailed description of their operations would lead us into a prolixity, of which the plan of our work does not admit.

I shall now give some examples of the operations of associating insects, who construct habitations by exerting a common and mutual labour.

The skill and dexterity of the honey-bees displayed in the construction of their combs or nests, have at all times called forth the admiration of mankind. They are composed of cells regularly applied to each other's sides. These cells are uniform hexagons or six-sided figures. In a beehive, every part is arranged with such symmetry, and so finely finished, that, if limited to the same materials, the most expert workman would find himself unqualified to construct a similar habitation, or rather a similar city.

Most Natural Historians have celebrated bees for their wisdom, for the perfection and harmony of their republican government, and for their persevering industry and wonderful economy. All these splendid talents, however, the late ingenious Count de Buffon has endeavoured to persuade us, are only results of pure mechanism. But this is not the proper place to enter into a discussion of this point. It will fall more naturally to be treated of when we come to describe the societies established among different gregarious animals. We shall, therefore, at present, confine ourselves chiefly to the mode in which bees construct their habitations.

In the formation of their combs, bees seem to resolve a problem which would not be a little puzzling to some geometers, namely, a quantity of wax being given, to make of it equal and similar cells of a determined capacity, but of the largest size in proportion to the quantity of matter employed, and disposed in such a manner as to occupy in the hive the least possible space. Every part of this problem is completely executed by the bees. By applying hexagonal cells to each other's sides, no void spaces are left between them; and, though the same end might be accomplished by other figures, yet they would necessarily require a greater quantity of wax. Besides, hexagonal cells are better fitted to receive the cylindrical bodies of these insects. A comb consists of two strata of cells applied to each other's ends. This arrangement both saves room in the hive, and it gives a double entry into the cells of which the comb is composed.

As a farther saving of wax, and preventing void spaces, the bases of these cells in one stratum of a comb serve for bases to the opposite stratum. In a word, the more minutely the construction of these cells is examined, the more will the admiration of the observer be excited. The walls of the cells are so extremely thin, that their mouths would be in danger of suffering by the frequent entering and issuing of the bees. To prevent this disaster, they make a kind of ring round the margin of each cell, and this ring is three or four times as thick as the walls.

It is difficult to perceive, even with the assistance of glass hives, the manner in which bees operate when constructing their cells. They are so eager to afford mutual assistance, and, for this purpose, so many of them crowd together, and are perpetually succeeding each other, that their individual operations can seldom be distinctly observed. It has, however, been plainly discovered, that their two teeth are the only instruments they employ in modelling and polishing the wax. With a little patience and attention, we perceive cells just begun; we likewise remark the quickness with which a bee moves its teeth against a small portion of the cell. This portion the animal, by repeated strokes on each side, smooths, renders compact, and reduces to a proper thinness of consistence. While some of the hive are lengthening their hexagonal tubes, others are laying the foundations of new ones. In certain circumstances, when extremely hurried, they do not complete their new cells, but leave them imperfect till they have begun a number sufficient for their present exigencies. When a bee puts its head a little way into a cell, we easily perceive it scraping the walls with the points of its teeth, in order to detach such useless and irregular fragments as may have been left in the work. Of these fragments the bee forms a ball about the size of a pin-head, comes out of the cell, and carries this wax to another part of the work where it is needed. It no sooner leaves the cell than it is succeeded by another bee, which performs the same office, and in this manner the work is successively carried on till the cell is completely polished.

The cells of bees are designed for different purposes. Some of them are employed for the accumulation and preservation of honey. In others, the female deposits her eggs, and from these eggs worms are hatched, which remain in the cells till their final transformation into flies. The drones, or males, are larger than the common, or working, bees; and the queen, or mother of the hive, is much larger than either. A cell destined for the lodgement of a male or female worm must, therefore, be considerably larger than the cells of the smaller working bees. The number of cells destined for the reception of the working bees far exceeds those in which the males are lodged. The honey-cells are always made deeper and more capacious than the others. When the honey collected is so abundant that the vessels cannot contain it, the bees lengthen, and of course deepen, the honey-cells.

Their mode of working, and the disposition and division of their labour, when put into an empty hive, do much honour to the sagacity of bees. They immediately begin to lay the foundations of their combs, which they execute with surprising quickness and alacrity. Soon after they begin to construct one comb, they divide into two or three companies, each of which, in different parts of the hive, is occupied with the same operations. By this division of labour, a greater number of bees have an opportunity of being employed at the same time, and, consequently, the common work is sooner finished. The combs are generally arranged in a direction parallel to each other. An interval, or street, between the combs is always left, that the bees may have a free passage, and an easy communication with the different combs in the hive. These streets are just wide enough to allow two bees to pass one another. Beside these parallel streets, to shorten their journey when working, they leave several round cross passages, which are always covered.

Hitherto we have chiefly taken notice of the manner in which bees construct and polish their cells, without treating of the materials they employ. We have not marked the difference between the crude matter collected from flowers and the true wax. Every body knows that bees carry into their hives, by means of their hind thighs, great quantities of the farina, or dust, of flowers. After many experiments made by Reaumur, with a view to discover whether this dust contained real wax, he was obliged to acknowledge, that he could never find that wax formed any part of its composition. He at length discovered, that wax was not a substance produced by the mixture of farina with any glutinous substance, nor by trituration, or any mechanical operation. By long and attentive observation, he found that the bees actually eat the farina which they so industriously collect; and that this farina, by an animal process, is converted into wax. This digestive process, which is necessary to the formation of wax, is carried on in the second stomach, and perhaps in the intestines of bees After knowing the place where this operation is performed, chemists will probably allow, that it is equally difficult to make real wax with the farina of flowers, as to make chyle with animal or vegetable substances, a work which is daily executed by our own stomach and intestines, and by those of other animals. Reaumur likewise discovered, that all the cells in a hive were not destined for the reception of honey and for depositing the eggs of the female, but that some of them were employed as receptacles for the farina of flowers, a species of food that bees find necessary for the formation of wax, which is the great basis and raw material of all their curious operations. When a bee comes to the hive with its thighs filled with farina, it is often met near the entrance by some of its companions, who first take off the load, and then devour the provisions so kindly brought to them. But, when none of the bees employed in the hive are hungry for this species of food, the carriers of the farina deposit their loads in cells prepared for that purpose. To these cells the bees resort, when the weather is so bad that they cannot venture to go to the fields in quest of fresh provisions. The carrying bees, however, commonly enter the hive loaded with farina. They walk along the combs beating and making a noise with their wings. By these movements they seem to announce their arrival to their companions. No sooner has a loaded bee made these movements, than three or four of those within leave their work, come up to it, and first take off its load, and then eat the materials it has brought. As a farther evidence that the bees actually eat the farina of flowers, when the stomach and intestines are laid open, they are often found to be filled with this dust, the grains of which, when examined by the microscope, have the exact figure, colour, and consistence of farina, taken from the antheræ of particular flowers After the farina is digested, and converted into wax, the bees possess the power of bringing it from their stomachs to their mouths. The instrument they employ in furnishing materials for constructing their waxen cells is their tongue. This tongue is situated below the two teeth or fangs. When at work, the tongue may be seen by the assistance of a lens and a glass hive. It is then in perpetual motion, and its motions are extremely rapid. Its figure continually varies.

Sometimes it is more sharp, at others it is flatter, and sometimes it is more or less concave, and partly covered with a moist paste or wax. By the different movements of its tongue, the bee continues to supply fresh wax to the two teeth, which are employed in raising and fashioning the walls of its cell, till they have acquired a sufficient height. As soon as the moist paste or wax dries, which it does almost instantaneously, it then assumes all the appearances and qualities of common wax. There is a still stronger proof that wax is the result of an animal process. When bees are removed into a new hive, and closely confined from the morning to the evening, if the hive chances to please them, in the course of this day several waxen cells will be formed, without the possibility of a single bee's having had access to the fields. Besides, the rude materials, or the farina of plants, carried into the hive, are of various colours. The farina of some plants employed by the bees is whitish; in others it is of a fine yellow colour; in others it is almost entirely red; and in others it is green. The combs constructed with these differently coloured materials are, however, uniformly of the same colour. Every comb, especially when it is newly made, is of a pure white colour, which is more or less tarnished by age, the operation of the air, or by other accidental circumstances. To bleach wax, therefore, requires only the art of extracting such foreign bodies as may have insinuated themselves into its substance, and changed its original colour.

Bees, from the nature of their constitution, require a warm habitation. They are likewise extremely solicitous to prevent insects of any kind from getting admittance into their hives. To accomplish both these purposes, when they take possession of a new hive, they carefully examine every part of it, and, if they discover any small holes or chinks, they immediately paste them firmly up with a resinous substance which differs considerably from wax. This substance was not unknown to the ancients. Pliny mentions it under the name of *propolis*, or bee-glue. Bees use the propolis for rendering their hives more close and perfect, in preference to wax, because the former is more durable, and more powerfully resists the vicissitudes of weather, than the latter. This glue is not, like wax, procured by an animal process. The bees collect it from different trees, as the poplars, the birches, and the willows. It is a complete production of nature, and requires no addition or manufacture from the animals by which it is employed. After a bee has procured a quantity sufficient to fill the cavities in its two hind thighs, it repairs to the hive. Two of its companions instantly draw out the propolis, and apply it to fill up such chinks, holes, or other deficiencies, as they find in their habitation. But this is not the only use to which bees apply the propolis. They are extremely solicitous to remove such insects or foreign bodies as happen to get admission into the hive. When so light as not to exceed their powers, they first kill the insect with their stings, and then drag it out with their teeth. But it sometimes happens that an ill-fated snail creeps into the hive. It is no sooner perceived than it is attacked on all sides and stung to death. But how are the bees to carry out a burden of such weight? This labour they know would be in vain. They are perhaps apprehensive that a body so large would diffuse, in the course of its putrefaction, a disagreeable or noxious odour through the hive. To prevent such hurtful consequences, immediately after the animal's death, they embalm it, by covering every part of its body with propolis, through which no effluvia can escape.—When a snail with a shell gets entrance, to dispose of it gives much less trouble and expense to the bees. As soon as this kind of snail receives the first wound from a sting, it naturally retires within its shell. In this case, the bees, instead of pasting it all over with propolis, content themselves with gluing all round the margin of the shell, which is sufficient to render the animal forever immovably fixed.

But propolis, and the materials for making wax, are not the only substances these industrious animals have to collect. As formerly remarked, beside the whole winter, there are many days in which the bees are prevented by the weather from going abroad in quest of provisions. They are, therefore, under the necessity of collecting, and laying up in cells destined for that purpose, large quantities of honey. This sweet and balsamic liquor they extract, by means of their proboscis or trunk, from the nectariferous glands of flowers. The trunk of a bee is a kind of rough cartilaginous tongue. After collecting a few small drops of honey, the animal with its proboscis conveys them to its mouth and swallows them. From the œsophagus, or gullet, it passes into the first stomach, which is more or less swelled in proportion to the quantity of honey it contains. When empty, it has the appearance of a fine white thread; but, when filled with honey, it assumes the figure of an oblong bladder, the membrane of which is so thin and transparent, that it allows the colour of the liquor it contains to be distinctly seen. This bladder is well known to children who live in the country. They cruelly amuse themselves with catching bees, and tearing them asunder, in order to suck the honey. A single flower furnishes but a small quantity of honey. The bees are, therefore, obliged to fly from one flower to another till they fill their first stomachs. When they have accomplished this purpose, they return directly to the hive, and disgorge in a cell the whole honey they have collected. It not unfrequently happens, however, that, when on its way to the hive, it is accosted by a hungry companion. How the one can communicate its necessity to the other, it is perhaps impossible to discover. But the fact is certain, that, when two bees meet in this situation, they mutually stop, and the one whose stomach is full of honey extends its trunk, opens its mouth, which lies a little beyond the teeth, and, like ruminating animals, forces up the honey into that cavity. The hungry bee knows how to take advantage of this hospitable invitation. With the point of its trunk it sucks the honey from the other's mouth. When not stopped on the road, the bee proceeds to the hive, and in the same manner offers its honey to those who are at work, as if it meant to prevent the necessity of quitting their labour in order to go in quest of food. In bad weather, the bees feed upon the honey laid up in open cells; but they never touch these reservoirs when their companions are enabled to supply them with fresh honey from the fields. But the mouths of those cells which are destined for preserving honey during winter, they always cover with a lid or thin plate of wax.

Wasps, like the bees, associate in great numbers, and construct, with much dexterity and skill, a common habitation. There are many species of wasps, some of which unite into societies, and others spend their lives in perfect solitude. But, in this place, we shall confine our attention to the operations of the common associating wasp, an insect so well known, even to children, that it requires no description. Though bees, as well as wasps, are armed with a sting, yet the former may be regarded as a placid and harmless race. Bees are continually occupied with their own labours. Their chief care is to defend themselves; and they never take nourishment at the expense of any other animal. Wasps, on the contrary, are ferocious animals, who live entirely on rapine and destruction. They kill and devour every insect that is inferior to them in strength. But, though warlike and rapacious in their general manners, they are polished and peaceable among themselves. To their young they discover the greatest tenderness and affection. For their protection and conveniency no labour is spared; and the habitations they construct do honour to their patience, address, and sagacity. Their architecture, like that of the honey-bee, is singular, and worthy of admiration; but the materials employed furnish neither honey nor wax. Impelled by an instinctive love of posterity, they, with great labour, skill, and assiduity, construct combs, which are likewise composed of hexagonal or six-sided cells. Though these cells are not made of wax, they are equally proper for the reception of eggs, and for affording convenient habitations to the worms which proceed from them till their transformation into wasps.

In general, the cells of the wasps are formed of a kind of paper, which, with great dexterity, is fabricated by the animals themselves. The number of combs and cells in a wasp's nest is always proportioned to the number of individuals associated. Different species choose different situations for building their nests. Some expose their habitations to all the injuries of the air; others prefer the trunks of decayed trees; and others, as the common kind, of which we are principally treating, conceal their nests under ground. The hole which leads to a wasp's nest is about an inch in diameter. This hole is a kind of gallery mined by the wasps, is seldom in a straight line, and varies in length from half a foot to two feet, according to the distance of the nest from the surface of the ground. When exposed to view, the whole nest appears to be of a roundish form, and sometimes about twelve or fourteen inches in diameter. Is is strongly fortified all round with walls or layers of paper, the surface of which is rough and irregular. In these walls or rather in this external covering, two holes are left for passages to the combs The wasps uniformly enter the nest by one hole, and go out by the other, which prevents any confusion or interruption to their common labours.

We are now arrived at the gates of this subterraneous city, which, though small, is extremely populous. Upon removing the external covering, we perceive that the whole interior part consists of several stories or floors of combs, which are parallel to each other, and nearly in a horizontal position.

Every story is composed of a numerous assemblage of hexagonal cells, very regularly constructed with a matter resembling ash-coloured paper. These cells contain neither wax nor honey, but are solely destined for containing the eggs, the worms which are hatched from them, the nymphs, and the young wasps till they are able to fly. Wasps' nests are not always composed of an equal number of combs. They sometimes consist of fifteen, and sometimes of eleven only. The combs are of various diameters. The first, or uppermost, is often only two inches in diameter, while those of the middle sometimes exceed a foot. The lowest are also much smaller than the middle ones. All these combs, like so many floors or stories ranged in a parallel manner above each other, afford lodging to prodigious numbers of inhabitants. Reaumur computed, from the number of cells in a given portion of comb, that, in a medium-sized nest, there were at least 10,000 cells. This calculation gives an idea of the astonishingly prolific powers of these insects, and the vast numbers of individuals produced in a single season from one nest; for every cell serves as a lodging to no less than three generations. Hence a moderately-sized nest gives birth annually to 30,000 young wasps.

The different stories of combs are always about half an inch high, which leaves free passages to the wasps from one part of the nest to another. These intervals are so spacious, that, in proportion to the bulk of the animals, they may be compared to great halls, or broad streets. Each of the larger combs is supported by about fifty pillars, which, at the same time, give solidity to the fabric, and greatly ornament the whole nest. The lesser combs are supported by the same ingenious contrivance. These pillars are coarse, and of a roundish form. Their bases and capitals, however, are much larger in diameter than the middle. By the one end they are attached to the superior comb, and by the other to the inferior. Thus between two combs there is always a species of rustic colonnade. The wasps begin at the top and build downward. The uppermost and smallest comb is first constructed. It is attached to the superior part of the external covering. The second comb is fixed to the bottom of the first; and in this manner the animals proceed till the whole operation is completed. The connecting pillars are composed of the same kind of paper as the rest of the nest.

To allow the wasps entries into the void spaces, roads are left between the combs and the external envelope or covering.

Having given a general idea of this curious edifice, it is next natural to inquire how the wasps build, and how they employ themselves in their abodes. But, as all these mysteries are performed under the earth, it required much industry and attention to discover them. By the ingenuity and perseverance of M. de Reaumur, however, we are enabled to explain some parts of their internal economy and manners. This indefatigable naturalist contrived to make wasps, like the honey-bees, lodge and work in glass-hives. In this operation he was greatly assisted by the ardent affection which these animals have to their offspring; for he found, that, though the nest was cut in different directions, and though it was exposed to the light, the wasps never deserted it, nor relaxed in their attention to their young. When placed in a glass hive, they are perfectly peaceable, and never attack the observer, if he calmly contemplates their operations; for, naturally, they do not sting, unless they are irritated.

Immediately after a wasp's nest has been transported from its natural situation, and covered with a glass hive, the first operation of the insects is to repair the injuries it has suffered. With wonderful activity they carry off all the earth and foreign bodies that may have accidentally been conveyed into the hive. Some of them occupy themselves in fixing the nest to the top and sides of the hive by pillars of paper similar to those which support the different stories or strata of combs; others repair the breaches it has sustained; and others fortify it by augmenting considerably the thickness of its external cover. This external envelope is an operation peculiar to wasps. Its construction requires great labour; for it frequently exceeds an inch and a half in thickness, and is composed of a number of strata or layers as thin as paper, between each of which there is a void space. This cover is a kind of box for inclosing the combs, and defending them from the rain which occasionally penetrates the earth. For this purpose it is admirably adapted. If it were one solid mass, the contact of water would penetrate the whole, and reach the combs. But, to prevent this fatal effect, the animals leave considerable vacuities between the vaulted layers, which are generally fifteen or sixteen in number. By this ingenious piece of architecture, one or two layers may be moistened with water, while the others are not in the least affected.

The materials employed by wasps in the construction of their nests are very different from those made use of by the honey-bee. Instead of collecting the farina of flowers, and digesting it into wax, the wasps gnaw with their two fangs, which are strong and serrated, small fibres of wood from the sashes of windows, the posts of espaliers, garden doors, &c. but never attempt growing or green timber. These fibres, though very slender, are often a line, or a twelfth part of an inch long. After cutting a certain number of them, the animals collect them into minute bundles, transport them to their nest, and, by means of a glutinous substance furnished from their own bodies, form them into a moist and ductile paste. Of this substance, or *papier maché*, they construct the external cover, the partitions of the nest, the hexagonal cells, and the solid columns which support the several layers or stories of combs.

The constructing of the nest occupies a comparatively small number of labourers. The others are differently employed. Here it is necessary to remark, that the republics of wasps, like those of the honey-bees, consist of three kinds of flies, males, females, and neuters. Like the bees, also, the number of neuters far surpasses those of both males and females. The greatest quantity of labour is devolved upon the neuters; but they are not, like the neuter bees, the only workers; for there is no part of their operations which the females, at certain times, do not execute. Neither do the males, though their industry is not comparable to that of the neuters, remain entirely idle. They often occupy themselves in the interior part of the nest. The greatest part of the labour, however, is performed oy the neuters. They build the nest, feed the males, the females, and even the young. But, while the neuters are employed in these different operations, the others are abroad in hunting parties. Some attack with intrepidity live insects, which they sometimes carry entire to the nest; but they generally transport the abdomen or belly only. Others pillage butchers' stalls, from which they often arrive with a piece of meat larger than the half of their own bodies. Others resort to gardens, and suck the juices of fruits. When they return to the nest, they distribute a part of their plunder to the females, to the males, and even to such neuters as have been usefully occupied at home. As soon as a neuter enters the nest, it is surrounded by several wasps, to each of whom it freely gives a portion of the food it has brought. Those who have not been hunting for prey, but have been sucking the juices of fruits, though they seem to return empty, fail not to regale their companions; for, after their arrival, they station themselves upon the upper part of the nest, and discharge from their mouths two or three drops of a clear liquid, which are immediately swallowed by the domestics.

The neuter wasps, though the most laborious, are the smallest; but they are extremely active and vivacious. The females are much larger, heavier, and slower in their movements. The males are of an intermediate size between that of the females and neuters. From these differences in size, it is easy to distinguish the different kinds of those wasps which build their nests below the ground. In the hive of the honey-bee, the number of females is always extremely small; but, in a wasp's nest, there are often more than three hundred females. During the months of June, July, and August, they remain constantly in the nest, and are never seen abroad except in the beginning of spring, and in the months of September and October. During the summer, they are totally occupied in laying their eggs and feeding their young. In this last operation, they are assisted by the other wasps; for the females alone, though numerous, would be insufficient for the laborious task. A wasp's nest, when completed, sometimes consists of sixteen thousand cells, each of which contains an egg, a worm, or a nymph. The eggs are white, transparent, of an oblong figure, and differ in size, according to the kind of wasps which are to proceed from them. Some of them are no larger than the head of a small pin. They are so firmly glued to the bottoms of the cells, that it is with difficulty they can be detached without breaking. Eight days after the eggs are deposited in the cells, the worms are hatched, and are considerably larger than the eggs which gave birth to them. These worms demand the principal cares of the wasps who continue always in the nest. They feed them, as birds feed their young, by giving them, from time to time, a mouthful of food. It is astonishing to see with what industry and rapidity a female runs along the cells of a comb, and distributes to each worm a portion of nutriment. In proportion to the ages and conditions of the worms, they are fed with solid food, such as the bellies of insects, or with a liquid substance disgorged by the mother. When a worm is so large as to occupy its whole cell, it is then ready to be metamorphosed into a nymph. It then refuses all nourishment, and ceases to have any connexion with the wasps in the nest. It shuts up the mouth of its cell with a fine silken cover, in the same manner as the silk-worm and other caterpillars spin their cods. This operation is completed in three or four hours, and the animal remains in the nymph state nine or ten days, when, with its teeth, it destroys the external cover of the cell, and comes forth in the form of a winged insect, which is either male, female, or neuter, according to the nature of the egg from which it was hatched. In a short time, the wasps newly transformed receive the food brought into the nest by the foragers in the fields. What is still more curious, in the course of the first day after their transformation, the young wasps have been observed going to the fields, bringing in provisions, and distributing them to the worms in the cells. A cell is no sooner abandoned by a young wasp, than it is cleaned, trimmed, and repaired by an old one, and rendered, in every respect, proper for the reception of another egg.

As formerly mentioned, wasps of different sexes differ greatly in size. The animals know how to construct cells proportioned to the dimensions of the fly that is to proceed from the egg which the female deposits in them. The neuters are six times smaller than the females, and their cells are built nearly in the same proportion. Cells are not only adapted for the reception of neuters, males, and females, but it is remarkable that the cells of the neuters are never intermixed with those of the males or females. A comb is entirely occupied with small cells fitted for the reception of neuter worms. But male and female cells are often found in the same comb. The males and females are of equal length, and, of course, require cells of an equal deepness. But the cells of the males are narrower than those of the females, because the bodies of the former are never so thick as those of the latter.

This wonderful assemblage of combs, of the pillars which support them, and of the external envelope, is an edifice which requires several months' labour, and serves the animals one year only. This habitation, so populous in summer, is almost deserted in winter, and abandoned entirely in spring; for, in this last season, not a single wasp is to be found in a nest of the preceding year. It is worthy of remark, that the first combs of a nest are always accommodated for the reception of the neuter or working wasps. The city, of which the foundation has just been laid, requires a number of workmen.

The neuter or working wasps are accordingly first produced. A cell is no sooner half-completed than an egg of a neuter is deposited in it by the female. Of fourteen or fifteen combs inclosed in a common cover, the four last only are destined for the reception of males and females. Hence it uniformly happens, that, before the males and females are capable of taking flight, every wasp's nest is peopled with several thousand neuters or workers. But the neuters, who are first produced, are likewise the first that perish; for not one of them survives the termination even of a mild winter. It was remarked by the ancient naturalists, that some wasps lived one year only, and others two. To the former, Aristotle gives the appellation of *operarii*, which are our workers or neuters, and to the latter *matrices*, which are our females.

The female wasps are stronger, and support the rigours of winter better, than the males or neuters. Before the end of winter, however, several hundred females die, and not above ten or a dozen in each nest survive that season. These few females are destined for the continuation of the species. Each of them becomes the founder of a new republic. When a queen-bee departs from a hive, in order to establish a new one, she is always accompanied with several thousand industrious labourers, ready to perform every necessary operation. But the female wasp has not the aid of a single labourer; for all the neuters are dead before the beginning of the spring. The female alone lays the foundation of a new republic. She either finds or digs a hole under the earth, builds cells for the reception of her eggs, and feeds the worms which proceed from them. Whenever any of these neuter worms are transformed into flies, they immediately assist their parent in augmenting the number of cells and combs, and in feeding the young worms, which are daily hatching from the eggs. In a word, this female wasp, which in spring was perfectly solitary, without any proper habitation, and had every operation to perform, has, in autumn, several thousands of her offspring at her devotion, and is furnished with a magnificent palace, or rather city, to protect her from the injuries of the weather and from external enemies.

With regard to the male wasps, it is uncertain whether any of them survive the winter. But, though not so indolent as the males of the honey-bee, they can be of little assistance to the female; for they never engage in any work of importance, such as constructing cells, or fortifying the external cover of the nest. They are never brought forth till towards the end of August; and their sole occupation seems to be that of keeping the nest clean. They carry out every kind of filth, and the carcases of such of their companions as happen to die. In performing this operation, two of them often join, and, as mentioned in another place, when the load is too heavy, they cut off the head, and transport the dead animal at two different times.

The males and females are produced at the same time, and they are nearly equal in number. Like the male honey-bees, the male wasps are destitute of stings, but the females and neuters have stings, the poisonous liquor of which, when introduced into any part of the human body, excites inflammation, and creates a considerable degree of pain.

'The habitations and economy of the various species of Ants are equally curious with those which have been described. There are, as with the wasps and bees, individuals of three sorts; males and females, which have wings, and neuters, which are without them. The former desert the habitations in which they have been reared, as soon as they have undergone the last metamorphosis, and seldom revisit them. They live principally in the air like other insects, forming numerous swarms. The females, as soon as they are ready to deposit their eggs, wander from their place of birth, deprive themselves of their wings by means of their feet, and found a new establishment, whilst the males, having become entirely useless, all perish. A few of the females are seized by the neuters, confined in the original habitation, deprived of their wings, and obliged to lay their eggs there, and are then driven out to perish.

'The neuters are distinguished not only by the want of wings, but by the size of their head, the strength of their jaws, and the length of their feet. They have charge of the principal part of the labour of preparing for the reception and nourishment of the young. The nests of ants differ very much in different species. They are generally made in the earth. Some merely dig out the sand and form holes running in different directions, so that the habitation is almost entirely subterraneous. Others gather together particles of many different kinds, and raise mounds of considerable size above the surface of the earth in the form of domes. Others choose for their residence the trunks of old trees, the interior of which they pierce with holes passing in every direction. All the passages or galleries of which these habitations consist, terminate in an apartment designed for the reception of the young.

'The food of ants consists of fruit, insects and their larvæ, and the bodies of small quadrupeds and birds. The neuters, which are the providers for the whole establishment, are principally governed in their researches by the senses of touch and smell. With the fruits of their labours they feed the larvæ while in a helpless state. In warm weather they drag them up for the benefit of the heat to the outside of their holes, and at the approach of night or of bad weather, convey them back again into the recesses of their habitations. In short, all their labour and care are directed with a view to the accommodation and preservation of an offspring in which they really have no share. They defend them against the attack of all enemies, and risk for them their safety and their lives; and after watching them with unremitting assiduity until they have arrived at the perfect state, they will not then suffer them to leave the nest unless the weather be fine and propitious, when they permit them to take their departure.'

'The male and female ants perish at the approach of winter, but the neuters survive it, and pass the cold months in a dormant state in the recesses of their habitations. Their forethought and providence, then, in the provision of food has not for its object their own support, but that of their young; and in preparing for the winter, they have merely to render their habitations tight and secure against the cold.'

The habitations and operations of the Termites, a species of insects frequently called white ants,* although of a different genus and even a different order from the common ants, are well worthy of attention. They infest Guinea, and all the tropical regions, where, for their depredations upon property, they are greatly dreaded by the inhabitants.

Of these insects there are several species; but they all resemble each other in form, and in their manner of living. They differ, however, as much as birds, in the style of their architecture, and in the selection of the materials of which their nests are composed. Some build on the surface, or

* In the windward parts of Africa, they are denominated *bugga*, bugs; in the West-Indies, *wood-lice*, *wood-ants*, or *white ants*. They are likewise called *piercers*, *eaters*, or *cutters*, because they cut almost every thing in pieces. This account of the termites is selected, with some slight alterations, from an excellent description of them in the Philosophical Transactions by Mr Henry Smeathman, vol. 71, part 1, p. 139.

partly above and partly below the ground, and others on the trunks or branches of lofty trees.

Before describing the nests or hills, it is necessary to give some idea of the animals themselves, and of their general economy and manners. We shall confine ourselves to that species called *termites bellicosi*, or fighters, because they are largest, and best known on the coast of Africa.

The republic of the *termites bellicosi*, like the other species of this genus, consists of three ranks or orders of insects: 1. The working insects, which Mr Smeathman distinguishes by the name of *labourers;* 2. The fighters, or *soldiers*, which perform no kind of labour; and, 3. The winged, or perfect insects, which are male and female. These last Mr Smeathman calls the *nobility* or *gentry;* because they neither labour nor fight. The nobility alone are capable of being raised to the rank of kings and queens. A few weeks after their elevation to this state, they emigrate, in order to establish new empires.

In a nest or hill, the labourers, or working insects, are always most numerous. There are at least one hundred labourers to one of the fighting insects or soldiers. When in this state, they are about a fourth of an inch in length, which is rather smaller than some of our ants. From their figure, and fondness for wood, they are very generally known by the name of *wood-lice.*

The second order, or soldiers, differ in figure from that of the labourers. The former have been supposed to be neuters, and the latter males. But, in fact, they are the same insects. They have only undergone a change of form, and made a nearer approach to the perfect state. They are now much larger, being half an inch in length, and equal in size to fifteen of the labourers. The form of the head is likewise greatly changed. In the labourer state, the mouth is evidently formed for gnawing or holding bodies; but, in the soldier state, the jaws being shaped like two sharp awls a little jagged, are destined solely for piercing or wounding. For these purposes they are very well calculated; for they are as hard as a crab's claw, and placed in a strong horny head, which is of a nut-brown colour, and larger than the whole body.

The figure of the third order, or that of the insect in its perfect state, is still more changed. The head, the thorax, and the abdomen, differ almost entirely from the same parts in the labourers and soldiers. Beside, the animals are now furnished with four large, brownish, transparent wings, by which they are enabled, at the proper season, to emigrate and to establish new settlements. In the winged or perfect state, they are greatly altered in their size as well as in their figure. Their bodies now measure between six and seven tenths of an inch, their wings, from tip to tip, above two inches and a half, and their bulk is equal to that of thirty labourers, or two soldiers. Instead of active, industrious, and rapacious little animals, when they arrive at their perfect state, they become innocent, helpless, and dastardly. Their numbers are great; but their enemies are still more numerous. They are devoured by birds, by every species of ants, by carnivorous reptiles, and even by the inhabitants of many parts of Africa.

Of those that escape, some are seized upon by the labouring insects, and are made the founders of new states. They are immediately inclosed in a chamber suitable to their size. This is built around them and has an entrance too small for them to go out, but large enough for the labourers to pass in and out. It was the opinion of former observers, that both males and females were thus preserved, but the analogy of other insects renders it probable that it is females alone. At any rate, there soon takes place a most extraordinary change in the female or queen. Her abdomen is gradually extended and enlarged to a most enormous size; so that in an old queen it has been found to have increased to 1500 or 2000 times the bulk of the rest of the body, and 20 or 30,000 times the bulk of a common labourer. The skin extends in every direction, so that the abdomen, which is not originally more than half an inch in length, has at length each of its segments removed to that distance from each other. When the animal is two years old, the abdomen has increased to three inches in length and they have sometimes been found of near twice that size. This is now full of eggs, which are contained in a vast number of very minute and convoluted vessels, which moving in a serpentine manner cause an undulating appearance without, like that of the peristaltic motion of the intestines. By means of this motion, the eggs are protruded in almost incredible numbers, to the amount, as has been pretty accurately calculated, of 80,000 or upward in twenty-four hours.

The eggs are instantly taken care of by the labourers and placed in proper depositories or nurseries where they are hatched. The young are then attended and provided with every thing necessary until they are able to shift for themselves and take their share in the labours of the community.

The nests of the termites bellicosi, or wood-lice, are called hills by the natives of Africa, New-Holland, and other hot climates. This appellation is highly proper; for they are often elevated ten or twelve feet above the surface of the earth, and are nearly of a conical figure. These hills, instead of being rare phenomena, are so frequent in many places near Senegal, that, as described with great propriety by Mons. Adanson, their number, magnitude, and closeness of situation, make them appear like villages of the negroes. "Of all the extraordinary things I observed," says Mons. Adanson, in his voyage to Senegal, "nothing struck me more than certain eminences, which, by their height and regularity, made me take them, at a distance, for an assemblage of negro huts, or a considerable village, and yet they were only the nests of certain insects. These nests are round pyramids, from eight to ten feet high, upon nearly the same base, with a smooth surface of rich clay, excessively hard and well built." Jobson, in his history of Gambia, tells us, that "the ant-hills are remarkable cast up in those parts by the pismires, some of them twenty foot in height, of compasse to contayne a dozen of men, with the heat of the sun baked into that hardnesse, that we used to hide ourselves in the ragged toppes of them, when we took up stands to shoot at deere or wild beasts." Mr Bosman remarks, in his description of Guinea, that "the ants make nests of the earth about twice the height of a man."

Each of these hills is composed of an exterior and an interior part. The exterior cover is a large clay shell, which is shaped like a dome. Its strength and magnitude are sufficient to enclose and protect the interior building from the injuries of the weather, and to defend its numerous inhabitants from the attacks of natural or accidental enemies. The external dome or cover is, therefore, always much stronger than the internal building, which is the habitation of the insects, and is divided with wonderful artifice and regularity into a vast number of apartments for the residence and accommodation of the king and queen, for the nursing of their progeny, and for magazines, which are always well stored with provisions.

These hills make their first appearance in the form of conical turrets, about a foot high. In a short time, the insects erect, at a little distance, other turrets, and go on increasing their number and widening their bases till their underworks are covered with these turrets, which the animals always raise highest in the middle of the hill, and, by filling up the intervals between each turret, collect them, at last, into one great dome.

The royal chamber appears to be, in the opinion of this little people, of the most consequence, and is always situated as near the centre of the interior building as possible, and generally about the height of the common surface of the ground. It is always nearly in the shape of half an egg, or an obtuse oval, within, and may be supposed to represent a long oven. In the infant state of the colony, it is not above an inch, or thereabouts, in length; but in time will be increased to six or eight inches, or more, in the clear, being always in proportion to the size of the queen, who increasing in bulk as in age, at length requires a chamber of such dimensions.

The royal chamber is surrounded by an innumerable quantity of others, which are of different sizes, figures, and dimensions; but all of them are arched either in a circular or an elliptical form. These chambers either open into each other, or have communicating passages, which, being always clear, are evidently intended for the conveniency of the soldiers and attendants, of whom, as will soon appear, great numbers are necessary. These apartments are joined by the magazines and nurseries. The magazines are chambers of clay, and are at all times well stored with provisions, which, to the naked eye, seem to consist of the raspings of wood and plants which the termites destroy; but, when examined by the microscope, they are found to consist chiefly of the gums or inspissated juices of plants, thrown together in small irregular masses. Of these masses, some are finer than others, and resemble the sugar about preserved fruits; others resemble the tears of gum, one being quite transparent, another like amber, a third brown, and a fourth perfectly opaque.

The magazines are always intermixed with the nurseries, which last are buildings totally different from the rest of the apartments. They are composed entirely of wooden materials, which seem to be cemented with gums. Mr Smeathman very properly gives them the appellation of nurseries; because they are invariably occupied by the eggs, and the young ones, which first appear in the shape of labourers; but they are as white as snow. These buildings are exceedingly compact, and are divided into a number of small, irregularly shaped chambers, not one of which is half an inch wide. They are placed all round, and as near as possible to the royal apartments.

When a nest or hillock is in the infant state, the nurseries are close to the royal apartment. But as, in process of time, the body of the queen enlarges, it becomes necessary, for her accommodation, to augment the dimensions of her chamber. She then, likewise, lays a greater number of eggs, and requires more attendants ; of course, it is necessary that both the number and dimensions of the adjacent apartments should be augmented. For this purpose, the small first-built nurseries are taken to pieces, rebuilt a little farther off, made a size larger, and their number, at the same time is increased. Thus the animals are continually employed in pulling down, repairing, or rebuilding their apartments; and these operations they perform with wonderful sagacity, regularity, and foresight.

One remarkable circumstance regarding the nurseries must not be omitted. They are always slightly overgrown with a kind of mould, and plentifully sprinkled with white globules about the size of a small pin's head. These globules, Mr Smeathman at first conjectured to be the eggs; but, when examined by the microscope, they evidently appeared to be a species of mushroom, in shape resembling our eatable mushroom when young. When entire, they are white like snow a little melted and frozen again ; and, when bruised, they seem to be composed of an infinite number of pellucid particles, approaching to oval forms, and are with difficulty separated from each other. The mouldiness seems likewise to consist of the same kind of substance.*

The nurseries are inclosed in chambers of clay, like those which contain the provisions; but they are much larger. In the early state of the nest, they are not bigger than a hazel nut; but, in great hills, they are often as large as a child's head a year old.

The royal chamber is situated nearly on a level with the surface of the ground, at an equal distance from all the sides of the building, and directly under the apex of the hill. On

* Mr Konig, who examined the termites' nests in the East-Indies, conjectures, that these mushrooms are the food of the young insects. This supposition implies, that the old ones have a method of providing for and promoting the growth of the mushroom ; "a circumstance," Mr Smeathman remarks, "which, however strange to those unacquainted with the sagacity of those insects, I will venture to say, from many other extraordinary facts I have seen of them, is not very improbable."

all sides, both above and below, it is surrounded by what are called the royal apartments, which contain only labourers and soldiers, who can be intended for no other purpose than to continue in the nest either to guard or serve their common parents, on whose safety the happiness, and, in the estimation of the negroes, the existence, of the whole community depends. These apartments compose an intricate labyrinth, which extends a foot or more in diameter from the royal chamber on every side. Here the nurseries and magazines of provisions begin; and, being separated by small empty chambers and galleries, which surround them, and communicate with each other, are continued on all sides to the outward shell, and reach up within it two thirds or three fourths of its height, leaving an open area in the middle under the dome, which resembles the nave of an old cathedral. This area is surrounded by large Gothic arches, which are sometimes two or three feet high next the front of the area, but diminish rapidly as they recede, like the arches of aisles in perspectives, and are soon lost among the innumerable chambers and nurseries behind them. All these chambers and passages are arched, and contribute mutually to support one another. The interior building, or assemblage of nurseries, chambers, and passages, has a flattish roof, without any perforation. By this contrivance, if, by accident, water should penetrate the external dome, the apartments below are preserved from injury. The area has also a flattish floor, which is situated above the royal chamber. It is likewise water-proof, and so constructed, that, if water gets admittance, it runs off by subterraneous passages, which are of an astonishing magnitude. "I measured one of them," says Mr Smeathman, "which was perfectly cylindrical, and thirteen inches in diameter." These subterraneous passages are thickly lined with the same kind of clay of which the hill is composed, ascend the internal part of the external shell in a spiral form, and, winding round the whole building up to the top, intersect and communicate with each other at different heights. From every part of these large galleries a number of pipes, or smaller galleries, leading to different parts of the building, proceed. There are likewise a great many which lead downward, by sloping descents, three and four feet perpendicular under ground, among the gravel, from which the labouring termites select the finer parts, which, after being worked up in their mouths to the consistence of mortar, become that solid clay or stone of which their hills, and every apartment of their buildings, except the nurseries, are composed. Other galleries ascend and lead out horizontally on every side, and are carried under ground, but near the surface, to great distances. Suppose the whole nests within a hundred yards of a house were completely destroyed, the inhabitants of those at a greater distance will carry on their subterraneous galleries, and invade the goods and merchandise contained in it by sap and mine, unless great attention and circumspection are employed by the proprietor.

When a breach is made in one of the hills, the first object that attracts attention is the behaviour of the soldiers, or fighting insects. Immediately after the blow is given, a soldier comes out, walks about the breach, and seems to examine the nature of the enemy, or the cause of the attack. He then goes into the hill, gives the alarm, and in a short time, large bodies rush out as fast as the breach will permit. It is not easy to describe the fury these fighting insects discover. In their eagerness to repel the enemy, they frequently tumble down the sides of the hill, but recover themselves very quickly, and bite every thing they encounter. This biting joined to the striking of their forceps upon the building, makes a crackling or vibrating noise, which is somewhat shriller and quicker than the ticking of a watch, and may be heard at the distance of three or four feet. While the attack proceeds, they are in the most violent bustle and agitation. If they get hold of any part of a man's body, they instantly make a wound, which discharges as much blood as is equal to their own weight. When they attack the leg, the stain of blood upon the stocking extends more than an inch in width. They make their hooked jaws meet at the first stroke, and never quit their hold, but suffer themselves to be pulled away leg by leg, and piece after piece, without the smallest attempt to escape. On the other hand, if a person keeps out of their reach, and gives them no farther disturbance, in less than half an hour they retire into the nest, as if they supposed the wonderful monster that damaged their castle had fled. Before the whole of the soldiers have got in, the labouring insects are all in motion, and hasten toward the breach, each of them having a quantity of tempered mortar in his mouth. This mortar they stick upon the breach as fast as they arrive, and perform the operation with so much despatch and facility, that, notwithstanding the immensity of their numbers, they never stop or embarrass one another. During this scene of apparent hurry and confusion, the spectator is agreeably surprised when he perceives a regular wall gradually arising and filling up the chasm. While the labourers are thus employed, almost all the soldiers remain within, except here and there one, who saunters about among six hundred or a thousand labourers, but never touches the mortar. One soldier, however, always takes his station close to the wall that the labourers are building. This soldier turns himself leisurely on all sides, and, at intervals of a minute or two, raises his head, beats upon the building with his forceps, and makes the vibrating noise formerly mentioned. A loud hiss instantly issues from the inside of the dome and all the subterraneous caverns and passages. That this hiss proceeds from the labourers is apparent; for, at every signal of this kind, they work with redoubled quickness and alacrity. A renewal of the attack, however, instantly changes the scene. On the first stroke, the labourers run into the many pipes and galleries with which the building is perforated, which they do so quickly, that they seem to vanish; for in a few seconds all are gone, and the soldiers rush out as numerous and as vindictive as before. On finding no enemy, they return again leisurely into the hill, and, very soon after, the labourers appear loaded as at first, as active, and as sedulous, with soldiers here and there among them, who act just in the same manner, one or other of them giving the signal to hasten the business. Thus the pleasure of seeing them come out to fight or to work, alternately, may be obtained as often as curiosity excites, or time permits; and it will certainly be found, that the one order never attempts to fight, nor the other to work, let the emergency be ever so great.

It is exceedingly difficult to explore the interior parts of a nest or hill. The apartments which surround the royal chamber and the nurseries, and indeed the whole fabric, have such a dependence on each other, that the breaking of one arch generally pulls down two or three. There is another great obstacle, namely, the obstinacy of the soldiers who dispute every inch of ground, and fight to the very last, wounding severely those who are engaged in the attempt, and sometimes obliging them to desist. Besides this, while the soldiers are engaged in defending the outworks, the labourers are barricading the way within, stopping up the different galleries and passages which lead to the various apartments, particularly the royal chamber, all the entrances to which they fill up so artfully as not to let it be distinguishable while it remains moist; and externally it has no other appearance than that of a shapeless lump of clay. It may be known, however, by its situation and by the crowd of soldiers and labourers who assemble around and within it, to defend or perish with it. It is never abandoned, and when taken out is always found full, the attendants running in one direction around the queen with the utmost solicitude, some of them stopping at her head as if to give her something, and others taking her eggs away from her and piling them carefully together in some part of the chamber.

CHAPTER IX.

OF THE HOSTILITIES OF ANIMALS.

In contemplating the system of animation exhibited in this planet, the only one of which we have any extensive knowledge, the mind is struck, and even confounded, with the general scene of havock and devastation which is perpetually, and every where, presented to our view. There is not, perhaps, a single species of animated beings, whose existence depends not, more or less, upon the death and destruction of others. Every animal, when not prematurely deprived of life by those who are hostile to it, or by accident, enjoys a temporary existence, the duration of which is longer or shorter according to its nature, and the rank it holds in the creation; and this existence universally terminates in death and dissolution. This is an established law of nature, to which every animal is obliged to submit. But this necessary and universal deprivation of individual life, though great, is nothing when compared to the havock occasioned by another law, which impels animals to kill and devour different species, and sometimes their own. In the system of nature, death and dissolution seem to be indispensable for the support and continuation of animal life.

But, though almost every animal, in some measure, depends for its existence on the destruction of others, there are some species in all the different tribes or classes, which are distinguished by the appellation of *carnivorous*, or *rapacious*, because they live chiefly, or entirely, on animal food. In the prosecution of this subject, therefore, we shall, in the first place, mention some examples of animal hostility and repacity; and, in the next place, endeavour to point out such advantages as result from this apparently cruel institution of nature. On the last branch of the subject, however, the reader must not expect to have every difficulty removed, and every question solved. Like all the other parts of the economy of nature, the necessity, or even the seeming cruelty and injustice, of allowing animals to prey upon one another, is a mystery which we can never be enabled completely to unravel. But we are not entirely without hopes of showing several important utilities which result from this almost universal scene of animal devastation.

Of all rapacious animals, Man is the most universal destroyer. The destruction of carnivorous quadrupeds, birds, and insects, is, in general, limited to particular kinds. But the rapacity of man has hardly any limitation. His empire over the other animals which inhabit this globe is almost universal. Of some of the quadruped tribes, as the horse, the dog, the cat, he makes domestic slaves; and though in this country, none of these species is used for food, he either obliges them to labour for him, or keeps them as sources of pleasure and amusement. From other quadrupeds, as the ox, the sheep, the goat, and the deer kind, he derives innumerable advantages. The ox kind in particular, after receiving the emoluments of their labour and fertility, he rewards with death, and then feeds upon their carcasses. Many other species, though not commonly used as food, are daily massacred in millions for the purposes of commerce, luxury, and caprice. Myriads of quadrupeds are annually destroyed for the sake of their furs, their hides, their tusks, their odoriferous secretions, &c.

Over the feathered tribes the dominion of man is not less extensive. There are few species in the numerous and diversified class of birds, which he either does not, or may not, employ for the nourishment of his body. By his sagacity and address he has been enabled to domesticate many of the more prolific and delicious species, as turkeys, geese, and the various kinds of poultry. These he multiplies without end, and devours at pleasure.

Neither do the inhabitants of the waters escape the rapacity of man. Rivers, lakes, and even the ocean itself, feel the power of his empire, and are forced to supply him with provisions. Neither air nor water can defend against the ingenuity, the art, and the destructive industry of the human species. Man may be said even to have domesticated some fishes. In artificial ponds, he feeds and rears carp, tench, perch, trout, and other species, and with them occasionally furnishes his table.

It might have been expected, that insects and reptiles, some of which have a most disgusting aspect, would not have excited the human appetite. But we learn from experience, that, in every region of the earth, many insects which inhabit both the earth and the waters, are esteemed as delicate articles of luxury. Even the viper, though its venom be deleterious, escapes not the all-devouring jaws of man.

Thus man holds, and too often exercises, a tyrannical dominion over almost the whole brute creation, not because he is the strongest of all animals, but because his intellect, though of a similar nature, is vastly superior to that of the most sagacious of the less favoured tribes. He reigns over the other animals, because the powers of his mind are more extensive. He overcomes force by ingenuity, and swiftness by art and persevering industry. But the empire of man over the brute creation is not absolute. Some species elude his power by the rapidity of their flight, by the swiftness of their course, by the obscurity of their retreats, and by the element in which they live. Others escape him by the minuteness of their bodies; and, instead of acknowledging their sovereign, others boldly attack him with open hostility. He is also insulted and injured by the stings of insects, and by the poisonous bites of serpents.

In other respects, man's empire, though comparatively great, is very much limited. He has no influence on the universe, on the motions and affections of the heavenly bodies, or on the revolutions of the globe which he inhabits. Neither has he a general dominion over animals, vegetables, or minerals. His power reaches not species, but is confined to individuals. Every order of beings moves on in its course, perishes, or is renewed, by the irresistible power of nature. Even man himself, hurried along by the general torrent of time and of nature, cannot prolong his existence. He is obliged to submit to the universal law; and, like all other organized beings, he is born, grows to maturity, and dies. Though man has been enabled to subdue the animal creation by the superior powers of his mind, his empire, like all other empires, could not be firmly established previous to the institution of pretty numerous societies. Almost the whole of his power is derived from society. It matures his reason, gives exertion to his genius, and unites his forces. Before the formation of large societies, man was perhaps the most helpless and the least formidable of all animals. Naked, and destitute of arms, to him the earth was only an immense desert peopled with strong and rapacious monsters, by whom he was often devoured. Even long after this period, history informs us, that the first heroes were destroyers of wild beasts. But, after the human species had multiplied, and spread over the earth, and when, by means of society and the arts, man was enabled to conquer a considerable part of the globe, he forced the wild beasts gradually to retire to the deserts. He reduced the numbers of the voracious and noxious species. He opposed the powers and the dexterity of one animal to those of another. Some he subdued by address, and others by force. In this manner he, in process of time, acquired to himself perfect security, and established an empire that has no other limits than inaccessible solitudes, burning sands, frozen mountains, or obscure caverns, which are occupied as retreats by a few species of ferocious animals.

Next to man, the carnivorous quadrupeds are the most numerous and the most destructive. Different parts of the earth are infested with lions, tigers, panthers, ounces, leopards, jaguars, couguars, lynxes, wild cats, dogs, jackals, wolves, foxes, hyænas, civets, genets, polecats, martins, ferrets, ermines, gluttons, bats, &c. Though all these, and many other tribes of quadrupeds, live solely upon blood and carnage, yet some of them, as the tiger, the wolf, the hyæna, and many other inferior species, are much more rapacious and destructive than others. The lion, though surrounded with prey, kills no more than he is able to consume. But the tiger is grossly ferocious, and cruel without necessity. Though satiated with carnage, he perpetually thirsts for blood. His restless fury has no intervals, except when he is obliged to lie in ambush for prey at the sides of lakes or rivers, to which other animals resort for drink. He seizes and tears in pieces a fresh animal with the same rage as he exerted in devouring the first. He desolates every country that he inhabits, and dreads neither the aspect nor the arms of man. He sacrifices whole flocks of domestic animals, and all the wild beasts which come within the reach of his terrible claws. He attacks the young of the elephant and rhinoceros, and sometimes even ventures to brave the lion. His predominant instinct is a perpetual rage, a blind and undistinguishing ferocity, which often impel him to devour his own young, and to tear their mother in pieces when she attempts to defend them. He delights in blood, and gluts himself with it till he is intoxicated. He tears the body for no other purpose than to plunge his head into it, and to drink large draughts of blood, the sources of which are generally exhausted before his thirst is appeased. The tiger is perhaps the only animal whose ferocity is unconquerable. Neither violence, restraint, nor bribery, have any effect in softening his temper. With harsh or gentle treatment he is equally irritated. The mild and conciliating influence of society makes no impression on the obduracy and incorrigibleness of his disposition. Time, instead of softening the ferociousness of his nature, only exasperates his rage. He tears, with equal wrath, the hand which feeds him, and that which is raised to strike him. Every animated object he regards as a fresh prey, menaces it with frightful groans, and often springs at it, without regarding his chains, which only restrain, but cannot calm his fury.

In temperate climates, the wolf seems to exceed all other animals in the ferocity and rapaciousness of his disposition. When pressed with hunger, he braves every danger. He attacks all those animals which are under the protection of man, especially such as he can carry off with ease, as lambs, kids, and the smaller kinds of dogs. When successful in his expeditions, he returns often to the charge, till, after being chased and wounded by men and dogs, he retires, during the day, to his den. In the night he again issues forth, traverses the country, roams round the cottages, kills all the animals that have been left without, digs the earth under the doors, enters with a terrible ferocity, and puts every living creature to death, before he chooses to depart, and carry off his prey. When these inroads happen to be fruitless, he returns to the woods, searches about with avidity, follows the track and the scent of wild beasts, and pursues them till they fall a prey to his rapacity. In a word, when his hunger is extreme, he loses all idea of fear, attacks women and children, and sometimes men; at last he becomes perfectly furious by excessive exertions, and generally falls a sacrifice to pure rage and distraction. When several wolves appear together, it is not an association of peace, but of war. It is attended with tumult and dreadful growlings, and indicates an attack upon some of the larger animals, as a stag, an ox, or a formidable mastiff. This depredatory expedition is no sooner ended than they separate, and every individual returns in silence to his solitude. Wolves are fond of human flesh. They have been known to follow armies, to come in troops to the field of battle, where bodies are carelessly interred, to tear them up, and to devour them with an insatiable avidity; and, when once accustomed to human flesh, these wolves ever after attack men, prefer the shepherd to the flock, devour women, and carry off children. Whole countries are sometimes obliged to arm, in order to destroy the wolves.

Neither are the feathered tribes exempted from the general law of devastation. But the number of birds of prey, properly so called, is much less in proportion than that of carnivorous quadrupeds. Birds of prey are likewise weaker; and, of course, the destruction of animal life they occasion is much more limited than the immense devastations daily committed by rapacious quadrupeds. But, as if tyranny never lost sight of its rights, great numbers of birds make prodigious depredations upon the inhabitants of the waters. A vast tribe of birds frequent the waters, and live solely upon fishes. In a certain sense, every species of bird may be said to be a bird of prey; for almost the whole of them devour flies, worms, and other insects, either for food to themselves or their young. Birds of prey, like carnivorous quadrupeds, are not so prolific as the milder and more inoffensive kinds. Most of them lay only a small number of eggs. The great eagle and the osprey produce only two eggs in a season. The pigeon, it may be said, lays no more. But it should be considered, that the pigeon produces two eggs, three, four, or five times, from spring to autumn. All birds of prey exhibit an obduracy and a ferociousness of disposition, while the other kinds are mild, cheerful, and gentle, in their aspect and manners. Most birds of prey expel their offspring from the nest, and relinquish them to their fate, before they are sufficiently able to provide for themselves. This cruelty is the effect of personal want in the mother. When prey is scanty, which often happens, she in a manner starves herself to support her young. But, when her hunger becomes excessive, she forgets her parental affection, strikes, expels, and sometimes, in a paroxysm of fury produced by want, kills her offspring. An aversion to society is another effect of this natural and acquired obduracy of temper. Birds of prey, as well as carnivorous quadrupeds, never associate. Like robbers, they lead a solitary and wandering life. Mutual attachment unites the male and the female ; and, as they are both capable of providing for themselves, and can give mutual assistance in making war against other animals, they never separate, even after the season of love. The same pair are uniformly found in the same place ; but they never assemble in flocks, nor even associate in families. The larger kinds, as the eagles, require a greater quantity of food, and, for that reason, never allow their own offspring, after they have become rivals, to approach the places which they frequent. But all those birds, and all those quadrupeds, which are nourished by the productions of the earth, live in families, are fond of society, and assemble in numerous flocks, without quarrelling or disturbing one another.

Both the earth and the air furnish examples of rapacious animals. In these elements, however, the number of carnivorous animals is comparatively small. But every inhabitant of the waters depends for its existence upon rapine and destruction. The life of every fish, from the smallest to the greatest, is one continued scene of hostility, violence, and evasion. Their appetite for food is almost insatiable. It impels them to encounter every danger. They are in continual motion ; and the object of all their movements is to devour other fishes, or to avoid their own destruction. Their desire for food is so keen and undistinguishing, that they greedily swallow every thing whic has the appearance of animation. Those that have small mouths feed upon worms and the spawn of other fishes ; and those whose mouths are larger devour every animal, their own species not excepted, that can pass through their gullet. To avoid destruction, the smaller fry retire to the shallows, where the larger kinds are unable to pursue them. But, in the watery element, no situation is absolutely safe ; for, even in the shallows, the oyster, the scallop, and the muscle, lie in ambush at the bottom, with their shells open, and, when a small fish comes into contact with them, they instantly close their shells upon him, and devour at leisure their imprisoned prey. Neither is the hunting or pursuit of fishes confined to particular regions. Shoals of one species follow, with unwearied ardour, those of another through vast tracts of the ocean. The cod pursues the whiting from the banks of Newfoundland to the southern coasts of Spain.

It is a remarkable circumstance in the history of animated nature, that carnivorous birds and quadrupeds are less prolific than the inoffensive and associating kinds; but, on the contrary, that the inhabitants of the waters, who are all carnivorous, are endowed with a most astonishing fecundity. All kinds of fishes, a few only excepted, are oviparous. Notwithstanding the amazing destruction of their eggs by the smaller fry that frequent the shores, by aquatic birds, and by the larger fishes, the numbers which escape are sufficient to supply the ocean with inhabitants, and to afford nourishment to a very great portion of the human race. A cod, for instance, according to the accurate computation, of Lewenhoeck, produces, from one roe, above nine millions of eggs in a single season. The flounder lays annually above one million, and the mackarel more than five hundred thousand; an increase so great, if permitted to arrive at maturity, that the ocean itself, in a few centuries, would not be spacious enough to contain its animated productions. This wonderful fertility answers two valuable purposes. In the midst of numberless enemies, it continues the respective species, and furnishes to all a proper quantity of nourishment.

We have thus seen that man, some quadrupeds, some birds, and all fishes, are carnivorous animals. But this system of carnage descends still lower. Many of the insect tribes derive their nourishment from putrid carcasses, from the bodies of living animals, or from killing and devouring weaker species. How many flies are daily sacrificed by spiders, a most voracious and a most numerous tribe? In return, spiders are greedily devoured by flies which are distinguished by the name of ichneumons. The number of these ichneumon-flies is inconceivable; and, if it were not for the prodigious havock they make upon caterpillars and other insects, the fruits of the earth would be entirely destroyed. Wasps are extremely fond of animal food. They frequent butchers' stalls, and beat off the flesh-fly, and every other insect that resorts thither for the purpose of depositing its eggs in the meat. Butchers take the advantage of this jealous warfare.

They encourage the wasps, and make centinels of them, by giving them livers, which they prefer to more fibrous flesh, probably because they can cut livers more easily with their teeth.

The libella, dragon, or lady-fly, is well known by the beauty of its colours and the symmetry of its form. For these external qualities it has received the appellation of lady-fly. Its dispositions and its mode of life, however, are more ferocious and warlike than those of the Amazons. Like birds of prey, they hover about in the air, for the sole purpose of devouring almost every species of winged insect. They, accordingly, frequent marshy grounds, pools of water, and the margins of rivers, where insects most abound. Their appetite is so gross and voracious, that they not only devour small flies, but even the large flesh-fly, moths, and butterflies, of every kind.

It has been often said, that no animal spontaneously feeds upon its own species. This remark has probably been intended as an apology for, or at least a limitation to, the general system of carnage established by nature. But, the observation, whatever might have been its intention, is unhappily a result of ignorance; for some quadrupeds, all fishes, and many insects, make no such discrimination. The weaker are uniformly preyed upon by the stronger. Reaumur put twenty of those caterpillars which feed upon the leaves of the oak into a vial. Though he regularly supplied them with plenty of fresh oak leaves, he observed that the number of dead ones daily increased. Upon a more attentive examination into the cause of this mortality, he found, that the stronger attacked with their teeth, killed, sucked out the vitals of their weaker companions, and left nothing but the head, feet, and empty skins. In a few days, one only of the twenty remained in life.

Caterpillars have myriads of external enemies, as birds of almost every kind, many of the smaller quadrupeds, their own species, and numberless insects. But this vast source of devastation is still augmented by what may be denominated their internal enemies. Many flies deposit their eggs in the bodies of caterpillars. From these eggs proceed small maggots, which gradually devour the vitals of the animal in which they reside. When about to be transformed into chrysalids, they pierce the skin of the caterpillar, spin their pods, and remain on the empty skin till they assume the form of flies, and escape into the air. Every person must recollect to have seen the colewort or cabbage caterpillar stuck upon old walls, or the windows of country cottages, totally covered with these chrysalids, which have the form of small maggots, and are of a fine yellow colour. One of the most formidable enemies of the caterpillar is a black worm, with six crustaceous legs. It is as long, and thicker than an ordinary sized caterpillar. In the fore part of the head it has two curved pincers, with which it quickly pierces the belly of a caterpillar, and never quits the prey till it is entirely devoured. The largest caterpillar is not sufficient to nourish this worm for a single day; for it daily kills and eats several of them. These gluttonous worms, when gorged with food, become inactive, and almost motionless. When in this satiated condition, young worms of the same species attack and devour them. Of all trees, the oak, perhaps, nourishes the greatest number of different caterpillars, as well as of different insects. Amongst others, the oak is inhabited by a large and beautiful beetle. This beetle frequents the oak, probably because that tree is inhabited by the greatest number of caterpillars. It marches from branch to branch, and, when disposed for food, attacks and devours the first caterpillar that comes in its way.

The pucerons, vine-fretters, or plant-lice, are very injurious to trees and vegetables of almost every kind. Their species are so numerous, and all of them are endowed with such a wonderful fertility, that we should expect to see the leaves, the branches, and the stems of every plant totally covered with them. But this astonishing fecundity, and the devastation these small insects would unavoidably produce among the vegetable tribes, is checked by numberless enemies. Myriads of insects of different classes, of different genera, and of different species, seem to be produced for no other purpose but to devour the pucerons. Some of these insects are so voracious, that, notwithstanding the extreme prolific powers of the pucerons, we have reason to be surprised that their species are not entirely annihilated. On every leaf inhabited by the puceron we find worms of different kinds. These worms feed not upon the leaves, but upon the pucerons, whom they devour with an almost incredible rapacity. Some of these worms are transformed into flies with two wings, others into flies with four wings, and others into beetles. While in the worm state, one of these gluttonous insects will suck out the vitals of twenty pucerons in a quarter of an hour. Reaumur supplied a single worm with more than a hundred pucerons, every one of which it devoured in less than three hours.

Beside the general system of carnage produced by the necessity of one animal's feeding upon another, a further source of destruction is found in the wars which man and many other animals wage with their own species. War among mankind, in certain accidental situations of society, may be productive, to particular nations or communities, of beneficial effects. But every advantage derived by war to one nation is acquired at the expense, and either the partial or the total ruin, of another. If universal peace could be completely established, and if the earth were cultivated to the highest perfection, it is not probable that the multiplication of the human species would ever rise to such a degree as to exceed the quantity of provisions produced by agriculture, and by the breeding of domestic animals, necessary for their existence and happiness. But, as long as men are actuated by ambition, by resentment, and by many other hostile passions, war and animosity, with all their train of bloodshed and calamity, will forever continue to harass and persecute the human kind. Let us, however, be humble. We cannot unfold the mysteries of Nature ; but we may admire her operations, and submit, with a becoming resignation, to her irresistible decrees. 'The man, if such a man there be, whose strength of mind enables him to observe steadfastly this conduct, is the only real philosopher.

But man is not the only animal that makes war with his own species. Quadrupeds, birds, fishes, insects, independently of their appetite for food, occasionally fight and kill each other. On this subject we shall confine ourselves to a few examples derived from the insect tribes.

A society or hive of bees consists of a female, of males or drones, and of neuters or working bees. These three kinds continue, for some time, in the most perfect harmony, and mutually protect and assist each other. The neuters, or working bees, discover the strongest attachment and affection to the males, even when in their worm state. The neuters are armed with a deadly sting, of which the males are destitute. Both are equally produced by the same mother, and live in the same family. But notwithstanding their temporary affection, there are times when the neuters cruelly massacre the males. Among the laws of polished republics, we find some which are extremely barbarous. The Lacedemonians were allowed to kill such of their children as were produced in a defective or maimed state, because they would become a burden upon the community. The laws of the Chinese permit actions equally inhuman. We perhaps know not all the reasons why the neuter bees treat the males with so much cruelty. There is a time, however, when the males become perfectly useless to the community; and it is not incurious to remark, that the general massacre never commences till this period arrives. Whenever a stranger bee enters a hive, his temerity is uniformly punished with death. But mortal combats are not unfrequent between bees belonging to the same hive. These combats are most frequent in clear and warm weather. Sometimes two combatants come out of the hive closely fastened to each other. At other times the attack is made in the air. But, in whatever way the battle begins, both combatants uniformly come to the ground before it is terminated by the death of one of the parties. When they reach the ground, each individual, like a wrestler, endeavours to gain the most advantageous position for stinging his adversary to death. Sometimes, though rarely, the sting is left in the wound. If this were generally the case, every combat would prove fatal to two bees; for the victor could not long survive the loss of his sting. These battles sometimes continue near an hour before one of the flies is left expiring on the ground.

Beside these single combats, general actions are not unfrequent, especially in the swarming season. When two swarms, or colonies, happen to contend for the same habitation, a general and bloody engagement immediately ensues. These engagements often continue for hours, and never terminate without great havock on both sides. The sting is not the only weapon employed in war by bees. They are furnished with two strong fangs or teeth, with which they cruelly tear each other. Even in general engagements, all the combats are single. But, when the great slaughter of the males is committing, three or four neuters are not ashamed to attack a single fly.

Every wasp's nest, about the beginning of October, exhibits a singular and a cruel scene. At this season, the wasps cease to bring nourishment to their young. From affectionate mothers or nurses, they at once become barbarous stepmothers. They are worse; for they drag the young worms from their cells, and carry them out of the nest. Being thus exposed to the weather, and deprived of nourishment, every one of them unavoidably perishes. This devastation is not, like that of the honey-bees, confined to the male worms. Here no worm, of whatever denomination or sex, escapes the general and undistinguished massacre. Besides exposing the worms to the weather, the wasps kill them with their fangs. This fact seems to be a violation of parental affection, one of the strongest principles in animal nature. But the intentions of nature, though they may often elude our researches, are never wrong. What appears to us cruel and unnatural in this instinctive devastation committed annually by the wasps, is perhaps an act of the greatest mercy and compassion. Wasps are not, like the honey-bees, endowed with the instinct of laying up a store of provisions for winter subsistence. If not prematurely destroyed by their parents, the young must necessarily die a more cruel and lingering death, occasioned by hunger. Hence this seemingly harsh conduct in the economy of wasps, instead of affording an exception to the universal benevolence and wisdom of nature, is, in reality, a merciful institution. Besides, as the multiplication of wasps is prodigious, and as they are a noxious race both to man and other animals, and especially to many tribes of insects, if their increase were not checked by such a dreadful carnage, their depredations, in a few years, would annihilate other species, break the chain of nature, and even prove destructive to man and the larger animals.

The same instinctive slaughter, and probably for the same reasons, is made by the hornets. Towards the end of October, all the worms and nymphs are dragged out of the nest and killed. The neuters and males fall daily victims to the cold; so that, at the end of winter, a few fertile females only remain to continue the species.

According to the adopted plan, we shall finish this subject with some observations which may have a tendency to reconcile our minds to a system so destructive to individuals of every species, that humanity, when not enlightened by a ray of philosophy, is apt to revolt, and to brand nature with cruelty and oppression. Nature, it must be confessed, seems almost indifferent to individuals, who perish every moment in millions, without any apparent compunction. But, with regard to species of every description, her uniform and uninterrupted attention to the preservation and continuation of the great system of animation is conspicuous, and merits admiration. Life, it should appear, cannot be supported without the intervention of death. Through almost the whole of animated nature, as we have seen, nothing but rapine, and the destruction of individuals, prevail. This destruction, however, has its use. Every animal, after death, administers life and happiness to a number of others. In many animals, the powers of digestion, and of assimilation, are confined to animal substances alone. If deprived of animal food, such species, it is evident, could not exist. The chief force of this observation, it is admitted, is applicable solely to the carnivorous tribes, strictly so denominated. But, from the facts formerly enumerated, and from the daily experience of every man, it is apparent, that, perhaps, no animal does or can exist totally independent of food, that is or has been animated. Sheep, oxen, and all herbivorous animals, though not from choice, and even without consciousness, daily devour thousands of insects. This may be one reason why cattle of all kinds fatten so remarkably in rich pastures; for insects are always most numerous where the herbage is luxuriant. Nature is so profuse in her animated productions, that no food can be eat, and no fluid can be drunk, in which animal substances, either in a living or dead state, are not to be found.

To this reasoning it may be objected, why has Nature established a system so cruel? Why did she render it necessary that one animal could not live without the destruction of another? To such questions no answer can be either given or expected. No being, except the Supreme, can unfold this mystery. Perhaps it even exceeds the limits of possibility to establish such an extended system of animation upon any other foundation. From the general benevolence of the great Creator, we are warranted to conclude that this is really the case. But it is fruitless to dwell upon subjects which are inscrutable, and far removed beyond the powers of human intellect. We shall therefore descend, and endeavour to point out some advantages which result from this mysterious institution of nature.

The hostilities of animals give rise to mutual improvement. Animals improve, and discover a superiority of parts, in proportion to the number of enemies they have to attack or evade. The weak, and consequently timid, are obliged to exert their utmost powers in inventing and practising every possible mode of escape. Pure instinct powerfully prompts; but much is learned by experience and observation. Rapacious animals, on the contrary, by frequent disappointment, are obliged to provide against the cunning and alertness of their prey. Herbivorous animals, as they have little difficulty in procuring food, are proportionally stupid ; but they would be still more stupid, if they had no enemies to annoy them. Man, if his attention and talents were not excited by the animosities of his own species, by the attacks of ferocious animals, and even by those of the insect tribes, would be an indolent, an incurious, a dirty, and an ignorant animal. Those of the human race, accordingly, who procure their food with little or no industry, as we learn from a multitude of travellers and voyagers, are perfectly indolent and brutishly stupid. Timid animals never use the arts of defence, or provide against danger, except from three causes, pure instinct, which is implanted in their natures, imitation, and experience. By experience, timid animals are taught the arts of evasion. Flight is instinctive ; but the modifications of it are acquired by imitation and experience.

Hostilities, in some instances, seem to arise, not from a natural antipathy of one species to another, but from a scarcity of food. The celebrated Captain Cooke informs us, that, in Staten-Island, birds of prey assemble promiscuously with penguins and other birds, without the one offering any injury, or the other discovering the smallest sympton of terror. In that island, the rapacious birds, perhaps, find plenty of food from dead seals, sea-lions, and fishes.

A profusion of animal life seems to be the general intention of nature. For this purpose, when not modified or restrained by the industry and intelligence of man, she uniformly covers the surface of the earth with trees and vegetables of every kind, which supply myriads of animated beings with food. But the greatest possible extension of life would still be wanting, if animals did not prey upon each other. If all animals were to live upon vegetables alone, many species, and millions of individuals, which now enjoy life and happiness, could have no existence ; for the productions of the earth would not be sufficient to support them. But, by making animals feed upon each other, the system of animation and of happiness is extended to the greatest possible degree. In this view, nature, instead of being cruel and oppressive, is highly generous and beneficent.

To diminish the number of noxious animals, and to augment that of useful vegetables, has been the uniform scope of human industry. A few species of animals only are of immediate utility to man. These he either cultivates with care, or hunts for his prey. The ox, the sheep, the goat, and other animals which are under his peculiar protection, he daily uses for food. This is not cruelty. He has a right to eat them; for, like nature, though he occasionally destroys domestic amimals, a timid and docile race of beings, by his culture and protection he gives life and happiness to millions, which, without his aid, could have no existence. The number of individuals, among animals of this description, if they were not cherished and defended by man, would be extremely limited; for, by the mildness of their dispositions, the comparative weakness of their arms, and the universal and strong appetite for them by rapacious quadrupeds and birds of prey, though the species might, perhaps, be continued, the number of individuals would, of necessity, be very small.

There is a wonderful balance in the system of animal destruction. If the general profusion of the animated productions of nature had no other check than the various periods to which their lives, when not extinguished by hostilities of one kind or another, are limited, the whole would soon be annihilated by an universal famine, and the earth, instead of every where teeming with animals, would, unless repeopled by a new creation, exhibit nothing but a mute, a lifeless, and an inactive scene. If even a single species were permitted to multiply without disturbance, the food of other species would be exhausted, and, of course, a period would be put to their existence. The herbivorous and frugivorous races, if not restrained by the carnivorous, would soon increase to a hurtful degree. Carnivorous animals are the barriers fixed by nature to noxious inundations of other kinds. The carnivorous tribes may be compared to the hoe and the pruning hook, which, by diminishing the number of plants when too close, or lopping off their luxuriances, make the others grow to greater perfection. To those swarms of insects which cover the surface of the earth, are opposed an army of birds, an active, a vigilant, and a voracious race. Hares, rabbits, mice, rats, are exposed to the depredations of carnivorous quadrupeds and birds. The larger cattle, as the ox, the deer, the sheep, &c. are not exempted from enemies; and man, by the superiority of his mental powers, checks the multiplication of the carnivorous tribes, and maintains the balance and empire of the animal system. Those species which are endowed with uncommon fertility have the greatest number of enemies. The caterpillar, the puceron, and insects in general, one of the most prolific classes of animals, are attacked and devoured by numerous hostile bands. No species, however, is ever exhausted. The balance between gain and loss is perpetually preserved. The earth, the seas, the atmosphere, may be considered as an immense and variegated pasture. In this view, it is most judiciously cultivated and stocked by the numerous animated beings which it is destined to support. Every animal and every vegetable furnish subsistence to particular species. Thus, nothing of value is lost; and every species is abundantly supplied with food.

That the general balance of animation is constantly preserved, we learn from daily experience. The reader, however, I presume, will not be displeased to have some examples of the modes employed by nature to accomplish this effect suggested to him.

After an inundation of the Nile, the lower parts of Egypt are greatly infested with serpents, frogs, mice, and other vermin. At that period, the storks resort thither in immense multitudes, and devour the serpents, frogs, and mice, which, without this dreadful carnage, would be highly noxious to the inhabitants. Belon, a most ingenious and faithful French naturalist, remarks, that, in many places, the land could not be inhabited, if the storks did not destroy the amazing numbers of mice which frequently appear in Palestine, and other parts of the East bordering upon Egypt. The Egyptian vulture, says Hasselquist, is of singular benefit to that country. It eats up all the dung and offals in the towns, and the carcasses of camels, horses, asses, &c. in the fields, which, if not quickly devoured, would, in that warm climate, by their putrescency, be productive of disease and death to the inhabitants. Putrid carcasses, in all countries are both offensive to the nostrils and hurtful to health. But nature, by various instruments, soon removes the evil. An animal no sooner dies, than, in a very short time, he is consumed by bears, wolves, foxes, dogs, and ravens. In situations where these animals dare not approach, as in the vicinity of towns and villages, a dead horse, in a few days is devoured by myriads of maggots. In the uncultivated parts of America, serpents and snakes of different kinds abound. After it was discovered that swine greedily devoured serpents, hogs were uniformly kept by all new settlers. Caterpillars are destructive to the leaves and fruits of plants. Their numbers and varieties are immense. But their devastations are checked by many enemies. Without a profusion of caterpillars, most of the smaller birds, especially when young, could not be supported. By devouring the caterpillars, these birds preserve the fruits of the earth from total destruction.

Shell-fishes are extremely prolific, and so strongly fortified by nature, that their increase, one would imagine, would soon augment to a degree that might be hurtful to other species. Their noxious multiplication, however, is checked by numberless enemies. But their most destructive enemy is the trochus, which is a kind of sea-snail. This animal is furnished with a strong, muscular, hollow trunk, bordered at the extremity with a cartilage toothed like a saw. Against this instrument, which acts like an auger, no shell, however hard or thick, is a sufficient defence. These animals, called *trochi*, fix themselves upon an oyster or a muscle, bore through the shell with their trunk, and devour their prey at their leisure. The animal attacked, if a bivalve, may open or shut its shell; but no efforts of this kind can be of any avail; for the trochus remains immovably fixed till it has completely sucked out the vitals of its prey. In this cruel occupation, the trochus often continues for days, and even weeks, before the life of the animal attacked is fully extinguished. The operation of the trochus may be seen in the shells of many oysters, muscles, and other shell-fishes; for their shells are often pierced with a number of circular holes.

The amazing strength of the whale, one would imagine, would secure it from the insults of every other animal. But, beside the annual depredations made by man upon the cetaceous tribes, they are often attacked and killed by the sword-fish. The snout of this comparatively small animal is armed with a long, hard, projection of bone, each edge of which is furnished with a number of strong, flat, and sharp points, or teeth, some of which, especially near the snout, are an inch and a half in length. With this instrument the sword-fish boldly attacks the whale. The whale has no other defence but its tail, with which it endeavours to strike its antagonist. But, as the sword-fish is more active and nimble than the whale, he easily parries the blow by springing into the air, and renewing the attack with his saw-like instrument. Whenever he succeeds, the sea is dyed red with the blood issuing from the wound. The fury of the whale appears from the vehemence with which it lashes the waters, each stroke resounding like the report of a cannon.

Upon the whole, every animated being that inhabits this globe seems to be destined by nature, not for its own individual existence and happiness alone, but likewise for the existence and happiness of other animated beings. A circle of animation and of destruction goes perpetually round. This is the economy of nature. Different species of animals live by the mutual destruction of each other. Even among individual men, the strong too often oppress the weak; but on the other hand, the wise instruct the ignorant. These are the bonds of society, and the sources of improvement.

CHAPTER X.

OF THE ARTIFICES OF ANIMALS.

Many instances of the dexterity and artifices of different animals, in various parts of their manners and economy, have been occasionally mentioned in several of the foregoing chapters. This circumstance, to avoid repetitions, will necessarily render the present chapter proportionally short. The artifices practised by animals proceed from several motives, many of which are purely instinctive, and others are acquired by experience and imitation. Upon this subject we shall, as usual, give some examples, which may both amuse and inform the reader.

When a bear, or other rapacious animal, attacks cattle, they instantly join and form a phalanx for mutual defence. In the same circumstances, horses rank up in lines, and beat off the enemy with their heels. Pontoppidan tells us, that the small Norwegian horses, when attacked by bears, instead of striking with their hind legs, rear, and, by quick and repeated strokes with their fore feet, either kill the enemy, or oblige him to retire. This curious, and generally successful defence, is frequently performed in the woods, while a traveller is sitting on the horse's back. It has often been remarked, that troops of wild horses, when sleeping either in plains or in the forest, have always one of their number awake, who acts as a centinel, and gives notice of any approaching danger.

Margraaf informs us, that the monkeys in Brazil, while they are sleeping on the trees, have uniformly a centinel to warn them of the approach of the tiger or other rapacious animals; and that, if ever this centinel is found sleeping, his companions instantly tear him in pieces for his neglect of duty. For the same purpose, when a troop of monkeys are committing depredations on the fruits of a garden, a centinel is placed on an eminence, who, when any person appears, makes a certain chattering noise, which the rest understand to be a signal for retreat, and immediately fly off and make their escape.

The deer kind are remarkable for the arts they employ in order to deceive the dogs. With this view the stag often returns twice or thrice upon his former steps. He endeavours to raise hinds or younger stags to follow him, and to draw off the dogs from the immediate object of their pursuit. If he succeeds in this attempt, he then flies off with redoubled speed, or springs off at a side, and lies down on his belly to conceal himself. When in this situation, if by any means his foot is recovered by the dogs, they pursue him with more advantage, because he is now considerably fatigued. Their ardour increases in proportion to his feebleness; and the scent becomes stronger as he grows warm. From these circumstances the dogs augment their cries and their speed; and, though the stag employs more arts of escape than formerly, as his swiftness is diminished, his doublings and artifices become gradually less effectual. No other resource is now left him but to fly from the earth which he treads, and go into the waters, in order to cut off the scent from the dogs, when the huntsmen again endeavour to put them on the track of his foot. After taking to the water, the stag is so much exhausted that he is incapable of running much farther, and is soon *at bay*, or, in other words, turns and defends himself against the hounds. In this situation he often wounds the dogs, and even the huntsmen, by blows with his horns, till one of them cuts his hams to make him fall, and then puts a period to his life.

The fallow-deer is more delicate, less savage, and approaches nearer to the domestic state than the stag. They associate in herds, which generally keep together. When great numbers are assembled in one park, they commonly form themselves into two distinct troops, which soon become hostile, because they are both ambitious of possessing the same part of the enclosure. Each of these troops has its own chief or leader, who always marches foremost, and he is uniformly the oldest and strongest of the flock. The others follow him; and the whole draw up in order of battle, to force the other troop, who observe the same conduct, from the best pasture. The regularity with which these combats are conducted is singular. They make regular attacks, fight with courage, and never think themselves vanquished by one check; for the battle is daily renewed till the weaker are completely defeated, and obliged to remain in the worst pasture. They love elevated and hilly countries. When hunted, they run not straight out, like the stag, but double, and endeavour to conceal themselves from the dogs by various artifices, and by substituting other animals in their place. When fatigued and heated, however, they take the water; but never attempt to cross such large rivers as the stag. Thus, between the chase of the fallow-deer and of the stag, there is no material difference. Their sagacity and instincts, their shifts and doublings, are the same, only they are more frequently practised by the fallow-deer. As he runs not so far before the dogs, and is less enterprising, he has oftener occasion to change, to substitute another in his place, to double, return upon his former tracks, &c. which renders the hunting of the fallow-deer more subject to inconveniences than that of the stag.

The roe-deer is inferior to the stag and fallow-deer both in strength and stature; but he is endowed with more gracefulness, courage, and vivacity. His eyes are more brilliant and animated. His limbs are more nimble; his movements are quicker, and he bounds with equal vigour and agility. He is likewise more crafty, conceals himself with greater address, and derives superior resources from his instincts. Though he leaves behind him a stronger scent than the stag, which increases the ardour of the dogs, he knows how to evade their pursuit, by the rapidity with which he commences his flight, and by numerous doublings. He delays not his arts of defence till his strength begins to fail him; for he no sooner perceives that the efforts of a rapid flight have been unsuccessful, than he repeatedly returns upon his former steps; and, after confounding, by these opposite motions, the direction he has taken, after intermixing the present with the past emanations of his body, he, by a great bound, rises from the earth, and, retiring to a side, lies down flat upon his belly. In this immovable situation, he often allows the whole pack of his deceived enemies to pass very near him. The roe-deer differs from the stag in disposition, manners, and in almost every natural habit. Instead of associating in herds, they live in separate families. The two parents and the young go together, and never mingle with strangers. The females commonly produce two fawns, the one a male and the other a female. These young animals, who are brought up and nourished together, acquire a mutual affection so strong, that they never depart from each other. In a week or two after birth the fawns are able to follow their mother. When threatened with danger, she hides them in a close thicket; and, so strong is her parental affection, that, in order to preserve her offspring from destruction, she presents herself to be chased.

Hares possess not, like rabbits, the art of digging retreats in the earth. But they neither want instinct sufficient for their own preservation, nor sagacity for escaping their enemies. They form seats or nests on the surface of the ground, where they watch, with the most vigilant attention, the approach of any danger. In order to deceive, they conceal themselves between clods of the same colour with that of their own hair. When pursued, they first run with rapidity, and then double, or return upon their former steps. From the place of starting, the females run not so far as the males; but they double more frequently. Hares hunted in the place where they were brought forth, seldom remove to a great distance from it, but return to their form; and, when chased two days successively, on the second day they perform the samé doublings they had practised the day before. When hares run straight out to a great distance, it is a proof that they are strangers. "I have seen a hare," Fouilloux remarks, "so sagacious, that, after hearing the hunter's horn, he started from his form, and, though at the distance of a quarter of a league, went to swim in a pool, and lay down on the rushes in the middle of it, without being chased by the dogs. I have seen a hare, after running two hours before the dogs, push another from his seat, and take possession of it. I have seen others swim over two or three ponds, the narrowest of which was eighty paces broad. I have seen others, after a two hour's chase, run into a sheep-fold and lie down among them. I have seen others, when hard pushed, run in among a flock of sheep, and would not leave them. I have seen others, after hearing the noise of the hounds, conceal themselves in the earth. I have seen others run up one side of a hedge and return by the other, when there was nothing else between them and the dogs. I have seen others, after running half an hour, mount an old wall, six feet high, and clap down in a hole covered with ivy. Lastly, I have seen others swim over a river, of about eighty paces broad, oftener than twice, in the length of two hundred paces."

The fox has, in all ages and nations, been celebrated for craftiness and address. Acute and circumspect, sagacious and prudent, he diversifies his conduct, and always reserves some art for unforeseen accidents. Though nimbler than the wolf, he trusts not entirely to the swiftness of his course. He knows how to ensure safety, by providing himself with an asylum, to which he retires when danger appears. He is not a vagabond, but lives in a settled habitation and in a domestic state. The choice of situation, the art of making and rendering a house commodious, and of concealing the avenues which lead to it, imply a superior degree of sentiment and reflection. The fox possesses these qualities, and employs them with dexterity and advantage. He takes up his abode on the border of a wood, and in the neighbourhood of cottages. Here he listens to the crowing of the cocks and the noise of the poultry. He scents them at a distance. He chooses his time with great judgment and discretion. He conceals both his route and his design. He moves forward with caution, sometimes even trailing his body, and seldom makes a fruitless expedition. When he leaps the wall, or gets in underneath it, he ravages the court-yard, puts all the fowls to death, and then retires quietly with his prey, which he either conceals under the herbage, or carries off to his kennel. In a short time he returns for another, which he carries off in the same manner, but to a different place. In this manner he proceeds, till the light of the sun, or some movements perceived in the house, admonish him that it is time to retire to his den. He does much mischief to the bird-catchers. Early in the morning he visits their nets and their birdlime, and carries off successively all the birds that happen to be entangled. The young hares he hunts in the plains, seizes old ones in their seats, digs out the rabbits in the warrens, finds out the nests of partridges, quails, &c. seizes the mothers on the eggs, and destroys a prodigious number of game. Dogs of all kinds spontaneously hunt the fox. Though his odour be strong, they often prefer him to the stag or the hare. When pursued he runs to his hole; and it is not uncommon to send in terriers to detain him till the hunters remove the earth above, and either kill or seize him alive. The most certain method, however, of destroying a fox is to begin with shutting up the hole, to station a man with a gun near the entrance, and then to search about with the dogs. When they fall in with him he immediately makes for his hole. But, when he comes up to it, he is met with a discharge from the gun. If the shot misses him, he flies off full speed, takes a wide circuit, and returns again to the hole, where he is fired upon a second time; but, when he discovers that the entrance is shut, he darts away straight forward, with the intention of never revisiting his former habitation. He is next pursued by the hounds, whom he seldom fails to fatigue; because, with much cunning, he passes through the thickest part of the forest, or places of the most difficult access, where the dogs are hardly able to follow him; and, when he takes to the plains, he runs straight out, without either stopping or doubling. But the most effectual way of destroying foxes is to lay snares baited with live pigeons, fowls, &c. The fox is an exceedingly voracious animal. Besides all kinds of flesh and fishes, he devours, with equal avidity, eggs, milk, cheese, fruits, and particularly grapes. He is so extremely fond of honey, that he attacks the nests of wild bees. They at first put him to flight by numberless stings; but he retires for the sole purpose of rolling himself on the ground, and of crushing the bees. He returns to the charge so often, that he obliges them to abandon the hive, which he soon uncovers, and devours both the honey and the wax.

When the female perceives that her retreat is discovered, and that her young have been disturbed, she carries them off, one by one, into a new habitation. The fox sleeps in a round form, like the dog; but, when he only reposes himself, he lies on his belly with his hind legs extended. It is in this situation that he eyes the birds on the hedges and trees. The birds have such an antipathy against him, that they no sooner perceive him than they send forth shrill cries to advertise their neighbours of the enemy's approach. The jays and blackbirds, in particular, follow the fox from tree to tree, sometimes two or three hundred paces, often repeating the watch-cries. The Count de Buffon kept two young foxes, which, when at liberty, attacked the poultry; but after they were chained, they never attempted to touch a single fowl. A living hen was fixed near them for whole nights; and, though destitute of victuals for many hours, in spite of hunger and of opportunity, they never forgot that they were chained, and gave the hen no disturbance.

In Kamtschatka, the animals called *gluttons* employ a singular stratagem for killing the fallow-deer. They climb up a tree, and carry with them a quantity of that species of moss of which the deer are very fond. When a deer approaches near the tree, the glutton throws down the moss. If the deer stops to eat the moss, the glutton instantly darts down upon his back, and, after fixing himself firmly between the horns, tears out its eyes, which torments the animal to such a degree, that, whether to put an end to its torments, or to get rid of its cruel enemy, it strikes its head against the trees till it falls down dead. The glutton divides the flesh of the deer into convenient portions, and conceals them in the earth to serve for future provisions. The gluttons on the river Lena kill horses in the same manner.

There are several species of rats in Kamtschatka. The most remarkable kind is called *tegulchitch* by the natives. These rats make neat and spacious nests under ground. They are lined with turf, and divided into different apartments, in which the rats deposit stores of provisions for supporting them during the winter. It is worthy of remark, that the rats of this country never touch the provisions laid up for the winter, except when they cannot procure nourishment any where else. These rats, like the Tartars, change their habitations. Sometimes they totally abandon Kamtschatka for several years, and their retreat greatly alarms the inhabitants, which they consider as a presage of a rainy season, and of a bad year for hunting. The return of these animals is, of course, looked upon as a good omen. Whenever they appear, the happy news is soon spread over all parts of the country. They always take their departure in the spring, when they assemble in prodigious numbers, and traverse rivers, lakes, and even arms of the sea. After they have made a long voyage, they frequently lie motionless on the shore, as if they were dead. When they recover their strength, they recommence their march. The inhabitants of Kamtschatka are very solicitous for the preservation of these animals. They never do the rats any injury, but give them every assistance when they lie weakened and extended on the ground. They generally return to Kamtschatka about the month of October; and they are sometimes met with in such prodigious numbers, that travellers are obliged to stop two hours till the whole troop passes. The tract of ground they travel in a single summer is not less wonderful than the regularity they observe in their march, and that instinctive impulse which enables them to foresee, with certainty, the changes of times and of seasons.

With regard to Birds, their artifices are not less numerous nor less surprising than those of quadrupeds. The eagle and hawk kinds are remarkable for the sharpness of their sight, and the arts they employ in catching their prey. Their movements are rapid or slow, according to their intentions, and the situation of the animals they wish to devour. Rapacious birds uniformly endeavour to rise higher in the air than their prey, that they may have an opportunity of darting forcibly down upon it with their pounces. To counteract these artifices, nature has endowed the smaller and more innocent species of birds with many arts of defence. When a hawk appears, the small birds, if they find it convenient, conceal themselves in hedges or brush-wood. When deprived of this opportunity, they often, in great numbers, seem to follow the hawk, and to expose themselves unnecessarily to danger, while in fact, by their numbers, their perpetual changes of direction, and their uniform endeavours to rise above him, they perplex the hawk to such a degree, that he is unable to fix upon a single object; and, after exerting all his art and address, he is frequently obliged to relinquish the pursuit. When in the extremity of danger, and after employing every other artifice in vain, small birds have been often known to fly to men for protection. This is a plain indication that these animals, though they in general avoid the human race, are by no means so much afraid of man as of rapacious birds.

The ravens often frequent the seashores in quest of food. When they find their inability to break the shells of muscles, &c. to accomplish this purpose they use a very ingenious stratagem. They carry a muscle, or other shell-fish, high up in the air, and then dash it down upon a rock, by which means the shell is broken, and they obtain the end they had in view.

The woodpecker is furnished with a very long and flexible tongue. It feeds upon ants and other small insects. Nature has endowed this bird with a singular instinct. It knows how to procure food without seeing its prey. It attaches itself to the trunks or branches of decayed trees; and, wherever it perceives a hole or crevice, it darts in its long tongue, and brings it out loaded with insects of different kinds. This operation is certainly instinctive; but the instinct is assisted by the instruction of the parents; for the young are no sooner able to fly, than the parents, by the force of example, teach them to resort to trees, and to insert their tongues indiscriminately into every hole or fissure.

'A small bird of the hawk kind called the nine-killer has been observed at particular seasons of the year to catch grasshoppers, beetles, or other insects, kill them and stick them in a position entirely natural, upon the branches of trees or bushes, so that they appear, at first sight, as if alive. It is a common opinion where this bird is found, that it thus destroys nine insects every day, and hence its name; but as it is known not to feed upon insects itself, but principally upon small quadrupeds and birds, the object of this expedient is not perfectly obvious. Some have supposed that it was done merely for amusement. The most probable explanation, however, is, that the insects are intended by this little hawk as a decoy for the birds which it designs for its prey. This manœuvre is put in practice in the fall of the year, just before the severe frosts begin, which by killing the insects deprive the smaller birds of the food on which they have been accustomed to subsist. They are of course, in the season of scarcity, led to the bait their sagacious enemy has provided, and thus become an easy prey.'

Of the economy of the inhabitants of the water, as formerly remarked, our knowledge is extremely limited. But, as the ocean exhibits a perpetual and a general scene of attack and defence, the arts of assault and of evasion must, of course, be exceedingly various. For the preservation of some species of fishes, nature has armed them with strong and sharp pikes. Others, as the perch kind, are defended with strong, bony rays in their fins. Others, as the univalve shell-fish, retire into their shells upon the approach of danger. The bivalves and multivalves, when attacked, instantly shut their shells, which, in general, is a sufficient protection to them. Some univalves, as the limpet kind, attach themselves so firmly, by excluding the air, to rocks and stones, that, unless quickly surprised, no force inferior to that of breaking the shell can remove them. The flying-fish, when pursued, darts out of the water, and takes refuge in the air, in which it is for some time supported by the operation of its large and pliable fins. The torpedo is furnished with a remarkable apparatus for self-preservation. It repels every hostile attempt by an electrical stroke, which confounds and intimidates its enemies. Several fishes, and

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particularly the salmon kind, when about to generate, leave the ocean, ascend the rivers, deposit their eggs in the sand, and, after making a proper *nidus* for their future progeny, return to the ocean from whence they came. Others, as the herring kind, though they seldom go up rivers, assemble in myriads from all quarters, and approach the shores, or ascend arms of the sea, for the purpose of continuing the species, and cherishing their offspring. When that operation is performed, they leave the coasts, and disperse in the ocean, till the same instinctive impulse forces them to observe similar conduct the next season. This migration of salmons, herrings, and many other fishes, from the ocean to the rivers or shores, is of infinite advantage to mankind. It is upon their passage that such immense numbers are taken to be used as food, and thus became an important article of commerce.

The insect tribes, though comparatively diminutive, are not deficient in artifice and address. With much art the spider spins his web. It serves him the double purpose of a habitation, and of a machine for catching his food. With incredible patience and perseverance he lies in the centre of his web for days, and sometimes for weeks, before an ill-fated fly happens to be entangled. One species of spider, which is small, of a blackish colour, and frequents cottages or out-houses, I have known to live during the whole winter months almost without the possibility of receiving any nourishment; for, during that period, not a fly of any kind could be discovered in the apartment. If they had been in a torpid state, like some other animals, the wonder of their surviving the want of food so long would not have been so great. But, in the severest weather, and through the whole course of the winter, they were perfectly active and lively. Neither did they seem to be in the least emaciated.

The formica-leo, or ant-lion, is a small insect, somewhat resembling a wood-louse, but larger. Its head is flat, and armed with two fine moveable crotchets, or pincers. It has six legs, and its body, which terminates in a point, is composed of a number of membranous rings. In the sand, or in finely pulverized earth, this animal digs a hole in the form of a funnel, at the bottom of which it lies in ambush for its prey. As it always walks backward, it cannot pursue any insect. To supply this defect, it lays a snare for them, and especially for the ant, which is its favourite food. It generally lies concealed under the sand in the bottom of its funnel or trap, and seldom exhibits more than the top of its head. In digging a funnel, the formica-leo begins with tracing a circular furrow in the sand, the circumference of which determines the size of the funnel, which is often an inch deep. After the first furrow is made, the animal traces a second, which is always concentric with the first. It throws out the sand, as with a shovel, from the successive furrows or circles, by means of its square, flat head, and one of its fore legs. It proceeds in this manner till it has completed its funnel, which it does with surprising promptitude and address. At the bottom of this artful snare it lies concealed and immovable. When an ant happens to make too near an approach to the margin of the funnel, the sides of which are very steep, the fine sand gives way, and the unwary animal tumbles down to to the bottom. The formica-leo instantly kills the ant, buries it under the sand, and sucks out its vitals. It afterwards pushes out the empty skin, repairs the disorder introduced into its snare, and again lies in ambush for a fresh prey.

We formerly took some notice of that species of spider which carries her eggs in a bag attached to her belly. A spider of this kind was thrown into the funnel of a formica-leo. The latter instantly seized the bag of eggs, and endeavoured to drag it under the sand. The spider, from a strong love of offspring, allowed its own body to be carried along with the bag. But the slender silk by which it was fixed to the animal's belly broke, and a separation took place. The spider immediately seized the bag with her pincers, and exerted all her efforts to regain the object of her affections. But these efforts were ineffectual; for the formica-leo gradually sunk the bag deeper and deeper in the sand. The spider, however, rather than quit her hold, allowed herself to be buried alive. In a short time, the observer removed the sand, and took out the spider. She was perfectly unhurt; for the formica-leo had not made any attack upon her. But, so strong was her attachment to her eggs, that, though frequently touched with a twig, she would not relinquish the place which contained them.

When arrived at its full growth, the formica-leo gives up the business of an ensnaring hunter. He deserts his former habitation, and crawls about for some time on the surface of the earth. He at last retires under the ground, spins a round silken pod, and is soon transformed into a fly.

CHAPTER XI.

OF THE SOCIETY OF ANIMALS.

The associating principle, from which so many advantages are derived, is not confined to the human species, but extends, in some instances, to every class of animals.

It is remarked by Buffon, and some other authors, that the state of nature, which had long occupied the attention and researches of philosophers, was rejected by them after the discovery was made. In the estimation of the authors alluded to, the savage state is the state of nature. The first natural condition of mankind is the union of a male and female. These produce a family, who, from necessity, or, in other words, from parental and filial affection, continue together, and assist each other in procuring food and shelter. This family, like most families in established civil societies, feel their own weakness, and their inability to supply their wants without more powerful resources than their feeble exertions. When this wandering and defenceless family accidentally meet with another family in the same condition, nature, it is said, teaches them to unite for mutual support and protection. The association of two families may be considered as the first formation of a tribe or nation. When a number of tribes happen to unite, they only become a larger or more numerous nation. A single pair, it is true, if placed in a situation where plenty of food could be procured without much labour, might, in a succession of ages, produce any indefinite number. This is precisely the situation in which Moses has placed our first parents. He has added another circumstance highly favourable to a speedy population. Instead of the present brevity of human life, he informs us, that men, in the first periods of the world, lived and propagated several hundred years.

In countries thinly peopled with savages, it is extremely probable, that societies are formed by the gradual union of families and tribes. The increase of power arising from mutual assistance, and a thousand other comfortable circumstances, soon contribute to cement more firmly the associated members. Some of the arts of life, beside that of hunting, are occasionally discovered either by accident or by the ingenuity of individuals. In this manner, gradual advances are made from the savage to the civilized condition of mankind. This is a very short view of the origin of society, which has been adopted by most authors both ancient and modern, though many of them have derived the associating principle from very different, and even from opposite causes, which it is no part of our plan either to enumerate or to refute. Some writers, as Aristotle, and a few moderns, implicit followers of his opinions, deny that man is naturally a gregarious or associating animal. To render this notion consistent with the actual and universal state of the human race, these authors have had recourse to puerile conceits, and to questionable facts, which it would be fruitless to relate. Other writers, possessed of greater judgment and discernment, and less warped with vanity and hypothetical phantoms, have derived the origin of society from its real and only source, Nature herself.

That the associating principle is instinctive, hardly requires a proof. An appeal to the feelings of any human being, and to the universal condition of mankind, is sufficient. These feelings, it may be said, are acquired by education and habit. By these causes, it is true, our social feelings are strengthened and confirmed ; but their origin is coeval with the existence of the first human mind. Let any man attend to the eyes, the features, and the gestures of a child upon the breast, when another child is presented to it ; both instantly, previous to the possibility of instruction or habit, exhibit the most evident expressions of joy. Their eyes sparkle, their features and gestures demonstrate, in the most unequivocal manner, a mutual attachment, and a strong desire of approaching each other, not with a hostile intention, but with an ardent affection, which, in that pure and uncontaminated state of our being, does honour to human nature. When farther advanced, children who are strangers to each other, though their social appetite is equally strong, discover a mutual shyness of approach. This shyness, or modesty, however, is soon conquered by the more powerful instinct of association. They daily mingle and sport together. Their natural affections, which, at that period, are strong, and unbiassed by those selfish and vicious motives which too often conceal and thwart the intentions of nature, create warm friendships that frequently continue during their lives, and produce the most beneficial and cordial effects. When we thus see with our eyes, that the associating principle appears distinctly at so early a period, who will listen to those writers who choose to deny that man is, naturally, an associating or gregarious animal?

With regard to the advantages we derive from association, a volume would not be sufficient to enumerate them. Man, possesses a portion of the reasoning faculty highly superior to that of any other animal. He alone enjoys the power of communicating and expressing his ideas by articulate and artificial language. This inestimable prerogative is, perhaps, one of the greatest secondary bonds of society, and the greatest source of improvement to the human intellect. Without artificial language, though nature has bestowed on every animal a mode of expressing its wants and desires, its pleasures and pains, what a humiliating figure would the human species exhibit, even upon the supposition that they did associate? But, when language and association are conjoined, the human intellect, in the progress of time, arrives at a high degree of perfection. Society gives rise to virtue, honour, government, subordination, arts, science, order, happiness. All the individuals of a community conduct themselves upon a regulated system. Under the influence of established laws, kings and magistrates, by the exercise of legal authority, encourage virtue, repress vice, and diffuse, through the extent of their jurisdictions, the happy effects of their administration. In society, as in a fertile climate, human talents germinate and are expanded; the mechanical and liberal arts flourish; poets, orators, historians, philosophers, lawyers, physicians, and theologians, are produced. These truths are pleasant; and it were to be wished that no evils accompanied them. But, through the whole extent of nature, it would appear, from our limited views, that good and evil, pleasure and pain, are necessary and perpetual concomitants.

The advantages of society are immense and invaluable. But the inconveniences, hardships, injustice, oppressions, and cruelties, which too often originate from it, are great and lamentable. Even under the mildest and best regulated governments, animosities, jealousies, avarice, fraud, and chicane, are unfortunately never removed from our observation. In absolute monarchies, and particularly in despotic governments, the scenes of private and of general calamity and distress are often too dreadful to be described. Notwithstanding all these disadvantages, however, any government is preferable to anarchy; and the comforts, pleasures, and improvements, we receive from associating with each other, overbalance all the evils to which society gives rise.

From an attentive observation of the manners and economy of animals, society has been distinguished into two kinds, which have been called *proper*, and *improper*.—1. *Proper Societies* comprehend all those animals which not only live together in numbers, but carry on certain operations which have a direct tendency to promote the welfare and happiness of the community.—2. *Improper Societies* include all those animals which herd together, and love the company of each other, without carrying on any common operation.

1. *Proper Societies*.—It is almost needless to remark that man holds the first rank in animal associations of this kind. If men did not assist each other, no operation of any magnitude, or which could show any great superiority of talents above those of the brute creation, could possibly be effected. A single family, or even a few families united, like other carnivorous animals, might hunt their prey, and procure a sufficient quantity of food. They might, like the bear, lodge in the cavities of trees; they might occupy natural caves in the rocks; they might even build huts with branches of trees and with turf, and cement these gross materials with clay. This lowest and most abject view of human nature is not exaggerated. It were to be wished that this grovelling condition of mankind were fictitious, and that, in many regions of the globe, it did not, at this moment, exist. These operations of men, when only acquainted with the mere rudiments of society, indicate parts little superior to those of the brutes. Man, even in his most uninformed state, possesses the capacity for every species of knowledge and every exertion of genius. But it may be cherished, expanded, and brought gradually to perfection. It is by numerous and regularly established societies alone, that such glorious exhibitions of human intellect can be produced. What is the hut of a savage, when compared to the palace of a prince? or what his canoe, when compared to a first-rate ship of war?

Next to the intelligence exhibited in human society, that of the beavers is the most conspicuous. Their operations in preparing, fashioning, and transporting, the heavy materials for building their winter habitations, as formerly remarked, are truly astonishing; and, when we read their history, we are apt to think that we are perusing the history of man in a period of society not inconsiderably advanced. It is only by the united strength, and co-operation of numbers, that the beavers could be enabled to produce such wonderful effects;

for, in a solitary state, as they at present appear in some northern parts of Europe, the beavers are timid and stupid animals. They neither associate, nor attempt to construct villages, but content themselves with digging holes in the earth. Like men under the oppression of despotic governments, the spirit of the European beavers is depressed, and their genius is extinguished by terror, and by a perpetual and necessary attention to individual safety. The northern parts of Europe are now so populous, and the animals there are so perpetually hunted for the sake of their furs, that they have no opportunity of associating; of course, those wonderful marks of their sagacity, which they exhibit in the remote and uninhabited regions of North America, are no longer to be found. The society of beavers is a society of peace and of affection. They never quarrel or injure one another, but live together in different numbers, according to the dimensions of particular cabins, in the most perfect harmony. The principle of their union is neither monarchical nor despotic: For the inhabitants of the different cabins, as well as those of the whole village, seem to acknowledge no chief or leader whatever. Their association presents to our observation a model of a pure and perfect republic, the only basis of which is mutual and unequivocal attachment. They have no law but the law of love and of parental affection. Humanity prompts us to wish that it were possible to establish republics of this kind among mankind. But the dispositions of men have little affinity to those of the beavers.

The hamster, or German marmot, and some other quadrupeds of this kind, live in society, and assist each other in digging and rendering commodious their subterraneous habitations. The operations of the marmots have already been described; and the nature of their society, as they continue during the winter in a torpid state, is either less known, or does not excite so much admiration, as that of the beavers.

Pairing birds, in some measure may be considered as forming proper societies; because, in general, the males and females mutually assist each other in building nests and feeding their youug. But this society, except in the eagle tribes, commonly continues no longer than their mutual offspring are fully able to provide for themselves. None of the feathered tribes, as far as we know, unite in bodies, in order to carry on any operation common to the whole.

Neither do we learn from history that fishes ever associate for the purpose of executing any common operation. Many of them, as herrings, salmons, &c. assemble in multitudes at particular seasons of the year; but this association, to which they are impelled by instinct, has no common object; for each individual is stimulated to act in this manner by its own motives, and no general effect is produced by mutual exertions.

In proper societies, each individual not only attends to his own preservation and welfare, but all the members co-operate in certain laborious offices which produce many common advantages that could not otherwise be procured. In some societies, the general principle of association and of mutual labour is purely instinctive, though, in many cases, individuals learn, by observation and experience, to modify or accommodate this general principle according to particular accidents or circumstances; some examples of which have already been given in the chapter upon instinct.

The insect tribes furnish many instances of proper societies. The honey-bees not only labour in common with astonishing assiduity and art, but their whole attention and affections seem to centre in the person of the queen or sovereign of the hive. She is the basis of their association and of all their operations. When she dies by any accident, the whole community are instantly in disorder. All their labours cease. No new cells are constructed. Neither honey nor wax is collected. Nothing but perfect anarchy prevails, till a new queen or female is obtained. The government or society of bees is more of a monarchical than of a republican nature. The whole of the members of the state seem to respect and to be directed by a single female. This fact affords a strong instance of the force and wisdom of nature. The female alone is the mother of the whole hive, however numerous. Without her, the species could not be continued. Nature, therefore, has endowed the rest of the hive with a wonderful affection to their common parent. For the reception of her eggs, nature impels them to construct cells, and to lay up stores of provisions for winter subsistence. These operations proceed from pure instinctive impulses. But every instinct necessarily supposes a degree of intellect, a substratum to be acted upon, otherwise no impulse could be felt, and, of course, no action nor mark of intelligence could possibly be produced. That the intelligence, the government, and the sagacity of bees, have been frequently exaggerated, and as frequently misunderstood, no real philosopher, or natural historian, will pretend to deny. But to refuse to believe them possessed of any portion of intelligence, and to refer all their wonderful operations to a mere mechanical impulse, as is done by Buffon, is equally opposed to the dictates of common sense and of sound philosophy.

What are called the *common* caterpillars afford an instance of proper association. About the middle of summer, a butterfly deposits from three to four hundred eggs on the leaf of a tree, from each of which, in a few days, a young caterpillar proceeds. They are no sooner hatched than they begin to form a common habitation. They spin silken threads, which they attach to one edge of the leaf, and extend them to the other. By this operation they make the two edges of the leaf approach each other, and form a cavity resembling a hammock. In a short time, the concave leaf is completely roofed with a covering of silk. Under this tent the animals live together in mutual friendship and harmony. When not disposed to eat or to spin, they retire to their tent. It requires several of these habitations to contain the whole. According as the animals increase in size, the number of their tents is augmented. But these are only temporary and partial lodgements, constructed for mutual conveniency, till the caterpillars are in a condition to build one more spacious, and which will be sufficient to contain the whole. After gnawing one half of the substance of such leaves as happen to be near the end of some twig or small branch, they begin their great work. In constructing this new edifice or nest, the caterpillars encrust a considerable part of the twig with white silk. In the same manner, they cover two or three of such leaves as are nearest to the termination of the twig. They then spin silken coverings of greater dimensions, in which they inclose the two or three leaves together with the twig. The nest is now so spacious that it is able to contain the whole community, every individual of which is employed in the common labour. These nests are too frequently seen, in autumn, upon the fruit trees of our gardens. They are still more exposed to observation in winter, when the leaves, which formerly concealed many of them, have fallen. They consist of large bundles of white silk and withered leaves, without any regular or constant form. Some of them are flat, and others roundish; but none of them are destitute of angles. By different plain coverings extended from the opposite sides of the leaves and of the twig, the internal part of the nest is divided into a number of different apartments. To each of these apartments, which seem to be very irregular, there are passages by which the caterpillars can either go out in quest of food, or retire in the evening, or during rainy weather. The silken coverings, by repeated layers, become at last so thick and strong, that they resist all the attacks of the wind, and all the injuries of the air, during eight or nine months. About the beginning of October, or when the frost first commences, the whole community shut themselves up in the nest. During the winter they remain immovable, and seemingly dead. But, when exposed to heat, they soon discover symptoms of life, and begin to creep. In this country, they seldom go out of the nest till the middle or end of April. When they shut themselves up for the winter, they are very small; but, after they have fed for some days in spring upon the young and tender leaves, they find the nest itself, and all the entrances to it, too small for the increased size of their bodies. To remedy this inconveniency, these disgusting reptiles know how to enlarge both the nest and its passages by additional operations accommodated to their present state. Into these new lodgings they retire when they want to repose, to screen themselves from the injuries of the weather, or to cast their skins. In fine, after casting their skins several times, the time of their dispersion arrives. From the beginning to near the end of June, they lead a solitary life. Their social disposition is no longer felt. Each of them spins a pod of coarse brownish silk. In a few days they are changed into chrysalids; and, in eighteen or twenty days more, they are transformed into butterflies.

Caterpillars of another species, which Reaumur distinguishes by the appellation of the *processionary caterpillar*, live in society till their transformation into flies. These caterpillars are of the hairy kind, and are of a reddish colour. They inhabit the oak, and feed upon its leaves. When very young, they have no fixed or general habitation. But, after they have acquired about one half of their natural size, they assemble together, and construct a nest sufficient to accommodate the whole. The nests of these caterpillars are attached to the trunks of the oak, and are situated sometimes near the earth, and sometimes seven or eight feet above its surface. They consist of different strata, or layers of silk, which are spun by the united labour of the whole community. Their figure is neither striking nor uniform. On the part of the oak to which they are fixed, they form a protuberance similar to those knots which are seen upon trees. This protuberance sometimes resembles a segment of a circle, and sometimes it is three or four times longer than it is broad. Some of these nests are from eighteen to twenty inches long, and from five to six inches wide. About the middle of their convexity, they often rise more than four inches above the surface of the tree. Between the trunk of the tree and the layers of silk a single hole is left, to allow the animals to go out in quest of food, and to retire into the nest after they are satiated. Notwithstanding the great bulk of these nests, and though there are often three or four of them upon the same tree, and never elevated above the height of distinct vision, they are not easily perceived; for the silk of which they are composed is cinereous, and resembles, in colour, those mosses with which the trunk of the oak is generally covered.

The inhabitants of a nest, which are numerous, march out, about the setting of the sun, to forage, under the conduct of a chief or leader, all whose movements they uniformly follow. The order they observe is singular. The first rank consists of single animals, the second of two, the third of three, the fourth of four, and sometimes more. In this manner they proceed in quest of food with all the regularity of disciplined troops. The chief or leader has no marks of pre-eminence; for any individual that happens first to issue from the nest, from that circumstance alone, becomes the leader of an expedition. After making a full repast upon the neighbouring leaves, they return to the nest in the same regular order; and this practice they continue during the whole period of their existence in the caterpillar state. It was from this strange regularity of movement that Reaumur, with much propriety, denominated these animals *processionary* caterpillars. When arrived at maturity, each individual spins a silken pod, is converted into a chrysalis, and afterwards assumes the form of a butterfly. This last transformation breaks all the bonds of their former association, and the female flies deposit their eggs, which, when hatched, produce new colonies, which exhibit the same economy and manners.

There are several species of caterpillars which are real republicans, and whose discipline, manners, and genius, are as diversified as those of the inhabitants of different nations and climates. Some, like particular savages, construct a kind of hammocks, in which they take their victuals, repose, and spend their lives till the period of their transformation. Others, like the Arabs and Tartars, construct and live in silken tents, and, after consuming the neighbouring herbage, they leave their former habitations, and encamp on fresh pasture. They go out of their tents at particular times in quest of food, and often to considerable distances; but they never lose their way back. It is not by sight that they are directed with so much certainty to their abodes. Nature has furnished them with another guide for regaining their habitations. We pave our streets with stones; but the caterpillars cover all their roads with silken threads. These threads make white tracks, which are often more than a sixth of an inch wide. It is by following these silken tracks, however complicated, that the caterpillars never miss their nests. If the road is broken by a man's finger drawn along it, or by any other accident, the caterpillars are greatly embarrassed. They stop suddenly at the interrupted space, and exhibit every mark of fear and of diffidence. Here the march stops, till an individual, more bold or more impatient than his companions, traverses the gap. In his passage, he leaves behind him a thread of silk, which serves as a bridge or conductor to the next that follows. By the progression of numbers, each of which spins a thread, the breach is soon repaired. We cannot suppose that these stupid animals cover their roads to prevent their wandering. But they never wander, because their roads are covered with silk. In this, as well as in many other instances, nature obliges animals to embrace the most effectual means of self-preservation, and even of conveniency, without their perceiving the utility of their own operations. The caterpillars, whose manners we have been describing, spin almost continually, because they are continually obliged to evacuate a silky matter, secreted from their food by vessels destined for that purpose, and included in their intestines. In obeying this call of nature, they effectually secure their retreat to their nests, and perhaps their existence. It may be said, that caterpillars associate for no other reason but because they are all produced at the same time from eggs deposited near each other. But many other species of caterpillars, which are brought to life in the very same circumstances, never associate or act in concert in the performance of any mutual labour. The silk-worms afford a familiar example. It is true they spontaneously remain assembled in the same place, which is of great advantage to manufacture. But the individuals of other species disperse immediately after birth, and never re-unite. Spiders, when newly hatched, begin with spinning a web in common; but they soon terminate this association by devouring one another.

As caterpillars do not engender till they arrive at the butterfly state, their associations have no respect to the rearing or education of young. Self-preservation and individual conveniency are the only bonds of their union. A perfect equality reigns among them, without any distinction of sex or even of size. Each takes his share of the common labour; and the whole society, which constitutes but one family, is the genuine issue of the same mother.

The association and economy of the common ants merit some attention. With wonderful industry and activity they collect materials for the construction of their nest. They unite in numbers, and assist each other in excavating the earth, and in transporting to their habitation bits of straw, small pieces of wood, and other substances of a similar kind, which they employ in lining and supporting their subterraneous galleries. The form of their nest or hill is somewhat conical, and, of course, the water, when it rains, runs easily off, without penetrating their abode. Under this hill there are many galleries or passages, which communicate with each other, and resemble the streets of a small city.

The ants not only associate for the purpose of constructing a common habitation, but for cherishing and protecting their offspring. Every person must have often observed, when part of a nest is suddenly exposed, their extreme solicitude for the preservation of their chrysalids or nymphs, which often exceed the size of the animals themselves. With amazing dexterity and quickness the ants transport their nymphs into the subterraneous galleries of the nest, and place them beyond the reach of any common danger. The courage and fortitude with which they defend their young is no less astonishing. The body of an ant was cut through the middle, and, after suffering this cruel treatment, so strong was its parental affection, with its head, and one half of the body, it carried off eight or ten nymphs. They go to great distances in search of provisions. Their roads, which are often winding and involved, all terminate in the nest.

The wisdom and foresight of the ants have been celebrated from the remotest antiquity. It has been asserted and believed, for near three thousand years, that they lay up magazines of provisions for the winter, and that they even cut off the germ of the grain to prevent it from shooting. But the ancients were never famed for accurate researches into the nature and operations of insects. These supposed magazines could be of no use to the ants; for, like the marmots and dormice, they sleep during the winter. A very moderate degree of cold is sufficient to render them torpid. In fact, it is now well known that they amass no magazines of provisions. The grains which, with so much industry and labour, they carry to their nest, are not intended to be food to the animals, but, like the bits of straw and wood, are employed as materials in the construction of their habitation.

2. *Improper Societies.*—Many animals are gregarious, though they unite not with a view to any joint operation, such as constructing common habitations, or mutually and indiscriminately nourishing and protecting the offspring produced by the whole society. But, even among animals of this description, there are motives or bonds of association, and, in many instances, they mutually assist and defend each other from hostile assaults.

The ox is a gregarious animal. When a herd of oxen are pasturing in a meadow, if a wolf makes his appearance, they instantly form themselves in battle array, and present their united horns to the enemy. This warlike disposition often intimidates the wolf, and obliges him to retire.

In winter, the hinds and young stags associate, and form herds, which are always more numerous in proportion to the severity of the weather. One bond of their society seems to be the advantage of mutual warmth derived from each other's bodies. In spring they disperse, and the hinds conceal themselves in the forests, where they produce their young. The young stags, however, continue together; they love to browse in company; and necessity alone forces them to separate.

The Count de Buffon represents sheep as stupid creatures, which are incapable of defending themselves against the attacks of any rapacious animal. He maintains that the race must long ago have been extinguished, if man had not taken them under his immediate protection. But nature has furnished every species of animated beings with weapons and arts of defence which are sufficient for individual preservation as well as for the continuation of the kind. Sheep are endowed with a strong associating principle. When threatened with an attack, like soldiers, they form a line of battle, and boldly face the enemy. In a natural state, the rams constitute one half of the flock. They join together and form the front. When prepared in this manner for repelling an assault, no lion or tiger can resist their united impetuosity and force.

A family of hogs, when in a state of natural liberty, never separate till the young have acquired strength sufficient to repel the wolf. When a wolf threatens an attack, the whole family unite their forces, and bravely defend each other.

The wild dogs of Africa hunt in packs, and carry on a perpetual war against other rapacious animals. The jackals of Asia and Africa likewise hunt in packs. But, though animals of this kind mutually assist each other in killing prey, individual advantage is the chief, if not the only, bond of this temporary union.

Another kind of society is observable among domestic animals. Horses and oxen, when deprived of companions of their own species, associate, and discover a visible attachment. A dog and an ox, or a dog and a cow, when placed in certain circumstances, though the species are remote, and even hostile, acquire a strong affection for each other. The same kind of association takes place between dogs and cats, between cats and birds, &c. If domestic animals had a strong aversion to one another, man could not derive so many advantages from them. Horses, oxen, sheep, &c. by browsing promiscuously together, augment and meliorate the common pasture. By living under the same roof, and feeding in common, this associating principle is strengthened and modified by habit, which often commences immediately after birth. A single horse confined in an enclosure, discovers every mark of uneasiness. He becomes restless, neglects his food, and breaks through every fence in order to join his companions in a neighbouring field. Oxen and cows will not fatten in the finest pasture, if they are deprived of society.

From the facts and remarks contained in this chapter, it seems to be evident, that the principle of association in man, as well as in many other animals, is natural; and that this principle may be strengthened and modified by the numberless advantages derived from it, by imitation, by habit, and by many other circumstances.

CHAPTER XI.

OF THE DOCILITY OF ANIMALS.

Of all animals capable of culture, man is the most ductile. By instruction, imitation, and habit, his mind may be moulded into any form. It may be exalted by science and art to a degree of knowledge of which the vulgar and uninformed have not the most distant conception. The reverse is melancholy. When the human mind is left to its own operations, and deprived of almost every opportunity of social information, it sinks so low, that it is nearly rivalled by the most sagacious brutes. It is not necessary, however, to enlarge upon a subject so familiar to the most common observer as the capacity of mankind for acquiring knowledge by observation and instruction. The bodies of men, though not so ductile as their minds, are capable, when properly managed by early culture, of wonderful exertions. Men accustomed to live in polished societies, have little or no idea of the activity, the courage, the patience, and the persevering industry of savages, when simply occupied in hunting wild animals for food to themselves and their families. The hunger, the fatigue, the hardships, which they not only endure with fortitude, but despise, would amaze and terrify the imagination of any civilized European.

Beside man, many other animals are capable of being instructed. The ape kind, and especially the larger species of them, imitate the actions of men without any instruction. This imitation they are enabled to perform with the greater exactness, on account of their structure, which approaches in many respects so nearly to that of the human species. The orang-outang is the most celebrated of these animals in this particular.

"The orang-outang," says Buffon, "which I saw, walked always on two feet, even when carrying things of considerable weight. His air was melancholy, his movements measured, his dispositions gentle, and very different from those of other apes. He had neither the impatience of the Barbary ape, the maliciousness of the baboon, nor the extravagance of the monkeys. It may be alleged that he had the benefit of instruction; but the apes, which I shall compare with him, were educated in the same manner. Signs and words were alone sufficient to make our orang-outang act; but the baboon required a cudgel, and the other apes a whip; for none of them would obey without blows. I have seen this animal present his hand to conduct the people who came to visit him, and walk as gravely along as if he had formed a part of the company. I have seen him sit down at table, unfold his towel, wipe his lips, use a spoon or a fork to carry the victuals to his mouth, pour his liquor into a glass, and make it touch that of the person who drank along with him. When invited to drink tea, he brought a cup and a saucer, placed them on the table, put in sugar, poured out the tea, and allowed it to cool before he drank it. All these actions he performed without any other instigation than the signs or verbal orders of his master, and often of his own accord. He did no injury to any person. He even approached company with circumspection, and presented himself as if he wanted to be caressed. He was very fond of dainties, which every body gave him; and, as his breast was diseased, and he was afflicted with a teazing cough, this quantity of sweetmeats undoubtedly contributed to shorten his life. He lived one summer in Paris, and died in London the following winter. He eat almost every thing; but preferred ripe and dried fruits to all other kinds of food. He drank a little wine; but spontaneously left it for milk, tea, or other mild liquors."

M. de la Brosse remarks of two orang-outangs, whose age exceeded not twelve months, that "These animals have the instinct of sitting at table like men. They eat every kind of food without distinction. They use a knife, a fork, or a spoon, to cut or lay hold of what is put upon their plate. They drink wine and other liquors. We carried them abroad. At table, when they wanted any thing, they made themselves understood by the cabin-boy; and, when the boy refused to give them what they demanded, they sometimes became enraged, seized him by the arm, bit, and threw him down.—The male was seized with sickness on the road. He made himself be attended as a human being. He was even twice bled in the right arm; and, whenever he found himself afterwards in the same condition, he held out his arm to be bled, as if he knew that he had formerly received benefit from that operation."

We are informed by Francis Pyrard, "that, in the province of Sierra Leona, there is a species of animals called *baris* (the orang-outang), which are strong and well limbed, and so industrious, that, when properly trained and fed, they work like servants; that they generally walk on the two hind feet; that they pound any substances in a mortar; that they go to bring water from the river in small pitchers, which they carry full on their heads. But when they arrive at the door, if the pitchers are not soon taken off, they allow them to fall; and, when they perceive the pitcher overturned and broken, they weep and lament." With regard to the education of these animals, the testimony of Schoutton corresponds with that of Pyrard. "They are taken," says he, "with snares, taught to walk on their hind feet, and to use their fore feet as hands in performing different operations, as rinsing glasses, carrying drink round the company, turning a spit,&c. Guat informs us, that he "saw at Java a very extraordinary ape. It was a female. She was very tall, and often walked erect on her hind feet. She made her bed very neatly every day, lay upon her side, and covered herself with the bedclothes.—When her head ached, she bound it up with her handkerchief; and it was amusing to see her thus hooded in bed. I could relate many other little articles which appeared to be extremely singular. But I admired them not so much as the multitude; because, as I knew the design of bringing her to Europe to be exhibited as a show, I was inclined to think that she had been *taught* many of these monkey tricks, which the people considered as being natural to the animal. She died in our ship, about the latitude of the Cape of Good Hope. The figure of this ape had a very great resemblance to that of man."

We have now enumerated the principal facts regarding this extraordinary animal, which have been related by voyagers of credit, and by those who have seen and examined him in Europe; and shall only remark, that, notwithstanding the great similarity of his structure and organs to those of the human species, his genius and talents seem to be very limited. The form of his body enables him to imitate every human action. But though he has the organs of speech, he is destitute of articulate language. If, however, he were domesticated, and proper pains bestowed for instructing him, he might possibly be taught to articulate. But, supposing this point to be obtained, if he remained incapable of reflection, if he was unable to comprehend the meaning of words, or to discover by his expressions a degree of intellect greatly superior to that of the brute creation, which I imagine would be the case, he could never, as some authors have held forth, be exalted to the distinguished rank of human beings.

Of all quadrupeds, of whose history and manners we have any proper knowledge, the elephant is one of the most remarkable both for docility and for understanding. Though his size is enormous, and his members rude and disproportioned, which give him, at first sight, the aspect of dulness and stupidity, his genius is great, and his sagacious manners, and his sedate and collected deportment, are almost incredible. He is the largest and strongest of all terrestrial animals. Though naturally brave, his dispositions are mild and peaceable. He is an associating animal, and seldom appears alone in the forests. When in danger, or when they undertake a depredatory expedition into cultivated fields, the elephants assemble in troops. The oldest takes the lead ; the next in seniority brings up the rear ; and the young and the feeble occupy the centre. In the forest and solitudes they move with less precaution ; but never separate so far asunder as to render them incapable of affording each other assistance when danger approaches. A troop of elephants constitutes a most formidable band. Wherever they march, the forest seems to fall before them. They bear down the branches upon which they feed ; and, if they enter an enclosure, they soon destroy all the labours of the husbandmen. Their invasions are the more tremendous, as there is hardly any means of repelling them ; for, to attack a troop, when thus united, would require a little army. It is only when one or two elephants happen to linger behind the rest that the hunters dare exert their art and ingenuity in making an attack ; for any attempt to disturb the troop would certainly prove fatal to the assailants. When an insult is offered, the elephants instantly move forward against the offender, toss him in the air with their tusks, and afterwards trample him to pieces under their feet, or rather pillars of flesh and bone. Let not the character of this noble, majestic animal, however, be misrepresented. With force and dignity he resents every affront ; but, when not disturbed by petulance or actual injury, he never shows an hostile intention either against man or any other animal. Elephants live entirely on vegetables, and have no thirst for blood. Such is their social and generous disposition, that, when an individual chances to meet with a luxurious spot of pasture, he immediately calls to his companions, and invites them to partake of his good fortune.

The elephant possesses all the senses in perfection ; but, in the sense of touching, he excels all the brute creation. His trunk is the chief instrument of this sense. In an elephant fourteen feet high, the trunk is about eight feet long, and five feet and half in circumference at the base. It is a large fleshy tube, divided through its whole extent by a septum or partition. It is capable of motion in every direction. The animal can shorten or lengthen it at pleasure. It answers every purpose of a hand; for it grasps large objects with great force, and its extremity can lay hold of a sixpence, or even of a pin. The trunk of the elephant affords him the same means of address as the ape. It serves the purposes of an arm and a hand. By this instrument, the elephant conveys large or small bodies to his mouth, places them on his back, embraces them fast, or throws them forcibly to a distance. In a state of nature and perfect freedom, the dispositions of the elephant are neither sanguinary nor ferocious. They are gentle creatures, and never exert their strength, or employ their weapons, but in defending themselves or protecting their companions. Even when deprived of the instruction of men, they possess the sagacity of the beaver, the address of the ape, and the acuteness of the dog. To these mental talents are added the advantages of amazing bodily strength, and the experience and knowledge he acquires by living at least two centuries. With his trunk he tears up trees. By a push of his body he makes a breach in a wall. To this prodigious strength he adds courage, prudence, and coolness of deportment. As he never makes an attack but when he receives an injury, he is universally beloved; and all animals respect, because none have any reason to fear him. In all ages, men have entertained a veneration for this most magnificent and sagacious of terrestrial creatures. The ancients regarded him as a miracle of nature, and he is, in reality, one of her greatest efforts. But they have greatly exaggerated his faculties. Without hesitation, they have ascribed to him high intellectual powers and moral virtues. Pliny, Ælian, Plutarch, and other authors of a more modern date, have bestowed on elephants not only rational manners, but an innate religion, a kind of daily adoration of the sun and moon, the use of ablution before worship, a spirit of divination, piety toward heaven and their fellow-creatures, whom they assist at the approach of death, and, after their decease, bedew them with tears, and cover their bodies with earth.

When tamed and instructed by man, the elephant is soon rendered the mildest and most obedient of all domestic animals. He loves his keeper, caresses him, and anticipates his commands. He learns to comprehend signs, and even to understand the expression of sounds. He distinguishes the tones of command, of anger, and of approbation, and regulates his actions by his perceptions. The voice of his master he never mistakes. His orders are executed with alacrity, but without any degree of precipitation. His movements are always measured and sedate, and his character seems to correspond with the gravity of his mass. To accommodate those who mount him, he readily learns to bend his knees. With his trunk he salutes his friends, uses it for raising burdens, and assists in loading himself. He loves to be clothed, and seems to be proud of gaudy trappings. In the southern regions, he is employed in drawing wagons, ploughs, and chariots. "I was eyewitness," says P. Philippe, "to the following facts. At Goa, there are always some elephants employed in the building of ships. I one day went to the side of the river, near which a large ship was building in the city of Goa, where there is a large area filled with beams for that purpose. Some men tie the ends of the heaviest beams with a rope, which is handed to the elephant, who carries it to his mouth, and, after twisting it round his trunk, draws it, without any conductor, to the place where the ship is building, though it had only once been pointed out to him. He sometimes drew beams so large that more than twenty men would have been unable to move them. But, what surprised me still more, when other beams obstructed the road, he elevated the ends of his own beams, that they might run easily over those which lay in his way. Could the most enlightened man do more?" When at work, the elephant draws equally, and if properly managed, never turns restive. The man who conducts the animal generally rides on his neck, and employs a hooked iron rod, or a bodkin, with which he pricks the head or sides of the ears, in order to push the creature forward, or to make him turn. But words are commonly sufficient. The attachment and affection of the elephant are sometimes so strong and durable that he has been known to die of grief, when, in an unguarded paroxysm of rage, he had killed his guide.

Before the invention of gunpowder, elephants were employed in war by the African and Asiatic nations. "From time immemorial," says Schoutton, "the kings of Ceylon, of Pegu, and of Aracan, have used elephants in war. Naked sabres were tied to their trunks, and on their backs were fixed small wooden castles, which contained five or six men armed with javelins, and other weapons." The Greeks and Romans, however, soon became acquainted with the nature of these monstrous warriors. They opened their ranks to let the animals pass, and directed all their weapons, not against the elephants, but their conductors. Since fire has now become the element of war, and the chief instrument of destruction, elephants, who are terrified both at the flame and noise, would be more dangerous than useful in our modern battles. The Indian kngs, however, still arm elephants in their wars. In Cochin, and other parts of Malabar, all the warriors who fight not on foot are mounted on elephants. The same practice obtains in Tonquin, Siam, and Pegu. In these countries, the kings and nobles at public festivals are always preceded and followed by numerous trains of elephants, pompously adorned with pieces of shining metal, and clothed with rich garments. Their tusks are ornamented with rings of gold and silver ; their ears and cheeks are painted with various colours ; they are crowned with garlands ; and a number of small bells are fixed to different parts of their bodies. They delight in gaudy attire ; for they are cheerful and caressing in proportion to the number and splendour of their ornaments. The Asiatics, who were very anciently civilized, perceiving the sagacity and docility of the elephant, educated him in a systematic manner, and modified his dispositions according to their own manners, and the useful labours in which his strength and dexterity could be employed.

A domestic elephant performs more labour than could be accomplished by six horses ; but he requires much care and a great deal of food. He is subject to be overheated, and must be led to the water twice or thrice a day. He easily learns to bathe himself. With his trunk he sucks up large quantities of water, carries it to his mouth, drinks part of it, and, by elevating his trunk, makes the remainder run over every part of his body. To give some idea of the labour he performs, and the docility of his disposition, it is worthy of remark, that, in India, bales, sacks, and tuns, are transported from one place to another, by elephants. They carry burdens on their bodies, their necks, their tusks, and even in their mouths, by giving them the end of a rope, which they hold fast with their teeth. Uniting sagacity with strength, they never break or injure any thing committed to their charge. From the margins of the rivers they put weighty bundles into boats without wetting them, lay them down gently and arrange them where they ought to be placed. When the goods are disposed as their masters direct, they examine with their trunks whether the articles are properly stowed; and if a cask or tun rolls, they go spontaneously in quest of stones to prop and render it firm.

In the elephant, the sense of smelling is acute, and he is passionately fond of odoriferous flowers, which he collects one by one, forms them into a nosegay, and, after gratifying his nose, conveys them to his mouth.

In India, the domestic elephants, to whom the use of water is as necessary as that of air, are allowed every possible conveniency for bathing themselves. The animal goes into a river till the water reaches his belly. He then lies down on one side, fills his trunk several times, and dexterously throws the water on such parts as happen to be uncovered. The master, after cleaning and currying one side, desires the animal to turn to the other, which command he obeys with the greatest alacrity; and, when both sides have been properly cleaned, he comes out of the river, and stands some time on the bank to dry himself. The elephant, though his mass be enormous, is an excellent swimmer; and, of course, he is of great use in the passage of rivers. When employed on occasions of this kind, he is often loaded with two pieces of cannon which admit three or four pound balls, beside great quantities of baggage and several men fixed to his ears and tail. When thus heavily loaded, he spontaneously enters the river and swims over with his trunk elevated in the air for the benefit of respiration. He is fond of wine and ardent spirits. By showing him a vessel loaded with any of these liquors, and promising him it as the reward of his labours, he is induced to exert the greatest efforts, and to perform the most painful tasks. The elephant is employed in dragging artillery over mountains, and, on these occasions, his sagacity and docility are conspicuous. Horses or oxen, when yoked to a cannon, make all their exertions to pull it up a declivity. But the elephant pushes the breech forward with his front, and, at each effort, supports the carriage with his knee, which he places against the wheel. He seems to understand what his *cornack*, or conductor, says to him. When his conductor wants him to perform any painful labour, he explains the nature of the operation, and gives the reasons which should induce him to obey. If the elephant shows a reluctance to the task, the cornack promises to give him wine, arrack, or any other article that he is fond of, and then the animal exerts his utmost efforts. But to break any promise made to him is extremely dangerous. Many cornacks have fallen victims to indiscretions of this kind. "At Dehan," says M. de Bussy, 'an elephant, from revenge, killed his cornack. The man's wife, who beheld the dreadful scene, took her two children, and threw them at the feet of the enraged animal, saying, *Since you have slain my husband, take my life also, as well as that of my children.* The elephant instantly stopped, relented,and, as if stung with remorse, took the eldest boy in its trunk, placed him on its neck, adopted him for its cornack, and would never allow any other person to mount it."

From the members of the Royal Academy of Sciences we learn some curious facts with regard to the manners of the Versailles elephant. This elephant, they remark, seemed to know when it was mocked, and remembered the affront till it had an opportunity of revenge. A man deceived it, by pretending to throw some food into its mouth. The animal gave him such a blow with its trunk as knocked him down, and broke two of his ribs. A painter wanted to draw the animal in an unusual attitude, with its trunk elevated, and its mouth open. The painter's servant, to make it remain in this position, threw fruits into its mouth, but generally made only a feint of throwing them. This conduct enraged the elephant; and, as if it knew that the painter was the cause of this teazing impertinence, instead of attacking the servant, it eyed the master, and squirted at him from its trunk such a quantity of water as spoiled the paper on which he was drawing. This elephant commonly made less use of its strength than of its address. It loosed, with great ease and coolness, the buckle of a large double leathern strap, with which its leg was fixed; and, as the servants had wrapped the buckle round with a small cord, and tied many knots upon it, the creature, with much deliberation, loosed the whole, without breaking either the strap or the cord.

It is remarked by le P. Vincent Marie, that the elephant, when in a domestic state, is highly esteemed for his gentleness, docility, and friendship to his governor. When destined to the immediate service of princes, he is sensible of his good fortune, and maintains a gravity of demeanour corresponding to the dignity of his situation. But if, on the contrary, less honourable labours are assigned to him, he grows melancholy, frets, and evidently discovers that he is humbled and depressed. He is fond of children, caresses them, and appears to discern the innocence of their manners. The Dutch voyagers relate, that by giving elephants what is

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agreeable to them, they are soon rendered perfectly tame and submissive. They are so sagacious, that they may be said to be destitute of the use of language only. They are proud and ambitious; and they are so grateful for good usage, that, as a mark of respect, they bow their heads in passing houses where they have been hospitably received. They allow themselves to be led and commanded by a child; but they love to be praised and caressed. When a wild elephant is taken, the hunters tie his feet, and one of them accosts and salutes him, makes apologies for binding him, protests that no injury is intended, tells him, that, in his former condition, he frequently wanted food, but that, henceforward, he shall be well treated, and that every promise shall be performed to him. This soothing harangue is no sooner finished than the elephant placidly follows the hunter. From this fact, however, we must not conclude that the elephant understands language, but that, like the dog, he has a strong discerning faculty. He distinguishes esteem from contempt, friendship from hatred, and many other emotions which are expressed by human gestures and features. For this reason, the elephant is more easily tamed by mildness than by blows.

"I have frequently remarked," says Edward Terry, "that the elephant performs many actions which seem to proceed more from reason than from instinct. He does every thing which his master commands. If he wants to terrify any person, he runs upon him with every appearance of fury, and, when he comes near, stops short, without doing him the smallest injury. When the master chooses to affront any man, he tells the elephant, who immediately collects water and mud with his trunk, and squirts it upon the object pointed out to him. The Mogul keeps some elephants who serve as executioners to criminals condemned to death. When the conductor orders one of these animals to despatch the poor criminals quickly, he tears them to pieces in a moment with his feet; but, if desired to torment them slowly, he breaks their bones one after another, and makes them suffer a punishment as cruel as that of the wheel."

Next to the elephant, the dog seems to be the most docile quadruped. A wild dog is a passionate, ferocious, and sanguinary animal. But, after he is reduced to a domestic state, these hostile dispositions are suppressed, and they are succeeded by a warm attachment, and a perpetual desire of pleasing. The perceptions and natural talents of the dog are acute.

When these are aided by instruction, the sagacity he discovers, and the actions he is taught to perform, often excite our wonder. Those animals which man has taken under his immediate protection are taught to perform artificial actions, or have their natural instincts improved, by three modes of instruction, punishment, reward, and imitation. More ductile in his nature than most other animals, the dog not only receives instruction with rapidity, but accommodates his behaviour and deportment to the manners and habits of those who command him. He assumes the very tone of the family in which he resides. Eager, at all times, to please his master, or his friends, he furiously repels beggars; because he probably, from their dress, conceives them to be either thieves, or competitors for food.

Though every dog, as well as every man, is naturally a hunter, the dexterity of both is highly improved by experience and instruction. The shepherd's dog, independently of all instruction, seems to be endowed by nature with an innate attachment to the preservation of sheep and cattle. His docility is likewise so great, that he not only learns to understand the language and commands of the shepherd, and obeys them with faithfulness and alacrity; but, when at distances beyond the reach of his master's voice, he often stops, looks back, and recognises the approbation or disapprobation of the shepherd by the mere waving of his hand. He reigns at the head of a flock, and is better heard than the voice of his master. His vigilance and activity produce order, discipline, and safety. Sheep and cattle are peculiarly subjected to his management, which he prudently conducts and protects, and never employs force against them, except for the preservation of peace and good order. But, when the flock committed to his charge is attacked by the fox, the wolf, or other rapacious animals, he makes a full display of his courage and sagacity. In situations of this kind, both his natural and acquired talents are exerted. Three shepherd's dogs are said to be a match for a bear, and four for a lion.

Every person knows the docility and sagacity of such dogs as are employed in conducting blind mendicants. A blind beggar used to be led through the streets of Rome by a middle-sized dog. This dog, beside leading his master in such a manner as to protect him from all danger, learned to distinguish not only the streets, but the houses where his master was accustomed to receive alms twice or thrice a week.

Whenever the animal came to any of these streets, with which he was well acquainted, he would not leave it till a call had been made at every house where his master was usually successful in his petitions. When the beggar began to ask alms, the dog, being wearied, lay down to rest; but the master was no sooner served or refused, than the dog rose spontaneously, and, without either order or sign, proceeded to the other houses where the beggar generally received some gratuity. When a halfpenny was thrown from a window, such was the sagacity and attention of this dog, that he went about in quest of it, lifted it from the ground with his mouth, and put it into his master's hat. Even when bread was thrown down, the animal would not taste it, unless he received a portion of it from the hand of his master. Without any other instruction than imitation, a mastiff, when accidentally shut out from a house which his master frequented, uniformly rung the bell for admittance. Dogs can be taught to go to market with money, to repair to a known butcher, and to carry home the meat in safety. They can be taught to dance to music, and to search for and find any thing that is lost.

There was a dog formerly belonging to a grocer in Edinburgh which for some time amused and astonished the people in the neighbourhood. A man who went through the streets ringing a bell and selling penny pies, happened one day to treat this dog with a pie. The next time he heard the pie-man's bell, he ran to him with impetuosity, seized him by the coat, and would not suffer him to pass. The pie-man, who understood what the animal wanted, showed him a penny, and pointed to his master, who stood in the street-door, and saw what was going on. The dog immediately supplicated his master by many humble gestures and looks. The master put a penny into the dog's mouth, which he instantly delivered to the pie-man, and received his pie. This traffick between the pie-man and the grocer's dog was daily practised for several months.

Dogs, horses, and even hogs, by rewards and punishments, and, I am afraid, often by cruelty, may be taught to perform actions, as we have frequently seen in public exhibitions, which are truly astonishing. But of these we must not enter into any detail.

With regard to the horse, the gentleness of his dispositions, and the docility of his temper, are so well and so universally known, that it is unnecessary to dwell long upon the subject. To give some idea of what instruction horses receive when in a domestic state, we shall mention some traits of their form and manners when under no restraints. In South America the horses have multiplied prodigiously, and, in that thinly inhabited country, live in perfect freedom. They fly from the presence of man. They wander about in troops, and devour, in immense meadows, the productions of a perpetual spring. Wild horses are stronger, lighter, and more nervous, than the generality of those which are kept in a domestic state. They are by no means ferocious. Though superior in strength to most animals, they never make an attack. When assaulted, however, they either disdain the enemy, or strike him dead with their heels. They associate in troops from mutual attachment, and neither make war with other animals nor among themselves. As their appetites are moderate, and they have few objects to excite envy or discord, they live in perpetual peace. Their manners are gentle, and their tempers social. Their force and ardour are rendered conspicuous only by marks of emulation. They are anxious to be foremost in the course, to brave danger in crossing a river, or in leaping a ditch or precipice; and, it is said, that those horses which are most adventurous and expert in these natural exercises, are, when domesticated, the most generous, mild, and tractable.

Wild horses are taken notice of by several of the ancients. Herodotus mentions white wild horses on the banks of the Hypanis, in Scythia. He likewise tells us, that, in the northern part of Thrace, beyond the Danube, there were wild horses covered all over with hair five inches in length. The wild horses in America are the offspring of domestic horses originally transported thither from Europe by the Spaniards. The author of the history of the Buccaneers informs us, that troops of horses, sometimes consisting of 500, are frequently met with in the island of St Domingo; that, when they see a man, they all stop; and that one of their number approaches to a certain distance, blows through his nostrils, takes flight, and is instantly followed by the whole troop. He describes them as having gross heads and limbs, and long necks and ears. The inhabitants tame them with ease, and then train them to labour. In order to take them, gins of ropes are laid in the places which they are known to frequent. When caught by the neck, they soon strangle themselves, unless some person arrive in time to disentangle them. They are tied to trees by the body and limbs, and are left in that situation two days without victuals or drink. This treatment is generally sufficient to render them more tractable, and they soon become as gentle as if they had never been wild. Even when any of these horses, by accident, regain their liberty, they never resume their savage state, but know their masters, and allow themselves to be approached and retaken.

From these, and similar facts, it may be concluded, that the dispositions of horses are gentle, and that they are naturally disposed to associate with man. After they are tamed they never forsake the abodes of men. On the contrary, they are anxious to return to the stable. The sweets of habit seem to supply all they have lost by slavery. When fatigued, the mansion of repose is full of comfort. They smell it at considerable distances, can distinguish it in the midst of populous cities, and seem uniformly to prefer bondage to liberty. By some attention and address colts are first rendered tractable. When that point is gained, by different modes of management, the docility of the animal is improved, and they soon learn to perform with alacrity the various labours assigned to them. The domestication of the horse is perhaps the noblest acquisition from the animal world, which has ever been made by the genius, the art, and the industry of man. He is taught to partake of the dangers and fatigues of war, and seems to enjoy the glory of victory. He encounters death with ardour and with magnanimity. He delights in the tumult of arms, and attacks the enemy with resolution and alacrity. It is not in perils and conflicts alone that the horse co-operates with the dispositions of his master. He even seems to participate of human pleasures and amusements. He delights in the chase and the tournament, and his eyes sparkle with emulation in the course. Though bold and intrepid, however, he does not allow himself to be hurried on by a furious ardour. On proper occasions, he represses his movements, and knows how to check the natural fire of his temper. He not only yields to the hand, but seems to consult the inclination, of his rider. Always obedient to the impressions he receives, he flies or stops, and regulates his motions solely by the will of his master.

Mr Ray, who wrote about the end of the seventeenth century, informs us, that he had seen a horse who danced to music, who, at the command of his master, affected to be lame, who simulated death, lay motionless with his limbs extended, and allowed himself to be dragged about, till some words were pronounced, when he instantly sprung up on his feet. Facts of this kind would scarcely receive credit, if every person were not now acquainted with the wonderful docility of the horses educated by public exhibitors of horsemanship. In exhibitions of this kind, the docility and prompt obedience of the animals deserve more admiration than the dexterous feats of the men.

Animals of the ox kind, in a domestic state, are dull and phlegmatic. Their sensibility and talents seem to be very limited. But we should not pronounce rashly concerning the genius and powers of animals in a country where their education is totally neglected. In all the southern provinces of Africa and Asia, there are many wild bisons, or bunched oxen, which are caught young and tamed. They are soon taught to submit, without resistance, to all kinds of domestic labour. They become so tractable, that they are managed with as much ease as our horses. The voice of their master is alone sufficient to make them obey, and to direct their course. They are shod, curried, caressed, and supplied abundantly with the best food. When managed in this manner, these animals appear to be different creatures from our oxen. The oxen of the Hottentots are favourite domestics, companions in amusements, assistants in all laborious exercises, and participate the habitation, the bed, and the table of their masters. As their nature is improved by the gentleness of their education, by the kind treatment they receive, and the perpetual attention bestowed on them, they acquire sensibility and intelligence, and perform actions which one would not expect from them. The Hottentots train their oxen to war. In all their armies there are considerable troops of these oxen, which are easily governed, and are let loose by the chief when a proper opportunity occurs. They instantly dart with impetuosity upon the enemy. They strike with their horns, kick, overturn, and trample under their feet every thing that opposes their fury. They run ferociously into the ranks, which they soon put in the utmost disorder, and thus pave the way for an easy victory to their masters. These oxen are likewise instructed to guard the flocks, which they conduct with dexterity, and defend them from the attacks of strangers and of rapacious animals. They are taught to distinguish friends from enemies, to understand signals, and to obey the commands of their master. When pasturing, at the smallest signal from the keeper, they bring back and collect the wandering animals. They attack all strangers, with fury, which renders them a great security against robbers. These *brackelays*, as they are called, know every inhabitant of the kraal, and discover the same marks of respect for all the men, women, and children, as a dog does for those who live in his master's house. These people may, therefore, approach their cattle with the greatest safety. But if a stranger, and particularly an European, should use the same freedom, without being accompanied with one of the Hottentots, his life would be in imminent danger.

Notwithstanding the many surprising actions which different quadrupeds may be taught to perform, none of them, though their organs are much more perfect than those of birds, have ever been able to pronounce articulate sounds. But many birds, without much instruction, learn to pronounce words and even sentences. In parrots, the distinguishing accuracy of their ear, the acuteness of their attention, and their strong instinctive propensity to imitate sounds of every kind, have justly procured them universal admiration. When in a state of domestication, the parrot learns to pronounce the common street calls, beside many words and phrases occasionally employed by the family in which he resides. Though the limitation of his mental powers does not permit him to learn any extent of language, or the proper use and meaning of words, he not unfrequently discovers the association between the object and the sound. A woman every morning passed the window, where a parrot's cage was fixed, calling salt. The parrot soon learned to imitate the call. But, before any sound could be heard, he no sooner cast his eye upon the woman than he uttered her usual call. In this and many other similar cases, the objects and the sounds are evidently connected in the mind of the animals. How far these associations might be carried by a patient and persevering education, it is difficult to determine. In this manner, however, parrots might be taught a considerable vocabulary of substantive nouns, or the proper names of common objects. But his intellect, it is more than probable, would never reach the use of the verb, and other parts of speech.

Beside parrots, jays, &c. who learn to pronounce articulate sounds, there is another race of birds whose docility deserves to be mentioned. Singing birds, those lively and spirited little animals, attempt not to articulate. But their musical ears are as delicate and discerning, as their voices are melodious and delightful. The vivacity, the extent of voice, and the imitative powers of these beautiful creatures, have at all times excited the attention and conciliated the affections of mankind. When domesticated, these birds, beside their natural notes, soon acquire the faculty of singing considerable parts of artificial tunes. These imitations are effects of natural instinct. But, in exhibitions, I have seen linnets simulate death, and remain perfectly tranquil and unmoved, when small cannons were fired, within an inch of their bodies, from a wooden fort. These little creatures have even been taught to lay hold of a match, and fire the cannons themselves.

We shall conclude this subject with a few remarks concerning the changes produced in animals by DOMESTICATION.

Climate and food are the chief causes which produce changes in the magnitude, figure, colour, and constitution of wild animals. But, beside these causes, there are others which have an influence upon animals when reduced to a domestic or unnatural state. When at perfect liberty, animals seem to have selected those particular zones or regions of the globe, which are most consonant to the nature and constitution of each particular tribe. There they spontaneously remain, and never, like man, disperse themselves over the whole surface of the earth. But when obliged by man, or by any great revolution of nature, to abandon their native soil, they undergo changes so great, that, to recognise and distinguish them, recourse must be had to the most accurate examination. If we add to climate and food, those natural causes of alteration in free animals, the empire of man over such of them as he has reduced to servitude, the degree to which tyranny degrades and disfigures nature, will appear to be greatly augmented. The mouflon, the stock from which our domestic sheep have derived their origin, is comparatively a large animal. He is as fleet as a stag, armed with horns and strong hoofs, and covered with coarse hair. With these natural advantages, he dreads neither the inclemency of the sky, nor the voracity of the wolf. He not only, by the swiftness of his course, escapes from his enemies, but he is enabled to resist them by the strength of his body and the solidity of his arms. How different is this animal from our domestic sheep, who are timid, weak, and unable to defend themselves. Without the protection of man, the whole race would soon be extirpated by rapacious animals and by winter storms. In the warmest climates of Africa and of Asia, the mouflon, which is the common parent of the sheep, appears to be less degenerated than in any other region. Though reduced to a domestic state, he has preserved his stature and his hair; but the size of his horns is diminished. The sheep of Barbary, Egypt, Arabia, Persia, &c. have undergone greater changes; and, in proportion as they approach toward either pole, they diminish in size, in strength, in swiftness, and in courage. In relation to man, they are improved in some articles, and vitiated in others. Their coarse hair is converted into fine wool But, with regard to nature, improvement and degeneration amount to the same thing; for both imply an alteration of the original constitution.

The ox is more influenced by nourishment than any other domestic animal. In countries where the pasture is luxuriant, the oxen acquire a prodigious size. To the oxen of Æthiopia and some provinces of Asia, the ancients gave the appellation of *Bull-Elephants*, because, in these regions, they approach to the magnitude of the elephant. This effect is chiefly produced by the abundance of rich and succulent herbage. The Highlands of Scotland, and indeed every high and northern country, afford striking examples of the influence of food upon the magnitude of cattle. The oxen, as well as the horses, in the more northern parts of Scotland, are extremely diminutive; but, when transported to richer pasture, their size is augmented, and the qualities of their flesh are improved. The climate has likewise a considerable influence on the nature of the ox. In the northern regions of both continents, he is covered with long soft hair. He has likewise a large bunch on his shoulders; and this deformity is common to the oxen of Asia, Africa, and America. Those of Europe have no bunch. The European oxen, however, seem to be the primitive race, to which the bunched kind ascend, by intermixture, in the second or third generation. The difference in their size is remarkably great. The small zebu, or bunched ox of Arabia, is not one tenth part of the magnitude of the Æthiopian bull-elephant.

The influence of food upon the dog kind seems not to be great. In all his variations and degradations, he appears to follow the differences of climate. In the warmest climates, he is naked; in the northern regions, he is covered with a coarse, thick hair; and he is adorned with a fine silky robe in Spain and Syria, where the mild temperature of the air converts the hair of most quadrupeds into a kind of silk. Beside these external variations produced by climate, the dog undergoes other changes, which proceed from his situation, his captivity, and the nature of the intercourse he holds with man. His size is augmented or diminished by obliging the smaller kinds to unite together, and by observing the same conduct with the larger individuals. Pendulous ears, the most certain mark of domestic servitude and of fear, are almost universal. Of many races of dogs, a few only have retained the primitive state of their ears. Erect ears are now confined to the wolf-dog, the shepherd's dog, and the dog of the north.

The colour of animals is greatly variegated by domestication. The dog, the ox, the sheep, the goat, the horse, have assumed all kinds of colours, and even mixtures of colours, in the same individuals. The hog has changed from black to white; and white, without the intermixture of spots, is generally accompanied with essential imperfections. Men who are remarkably fair, and whose hair is white, have generally a defect in their hearing, and, at the same time, weak and red eyes. Quadrupeds which are entirely white likewise have red eyes and a dulness of hearing.* The variations from the original colour are most remarkable in our domestic fowls. In a brood of chickens, though all of them proceed from the same parents, not one of them has the same colours with another.

Domestication not only changes the external appearances of animals, but alters and modifies their natural dispositions. The dog, for example, when in a state of liberty, is a rapacious quadruped, and hunts and devours the weaker species. But, after he has submitted to the dominion of man, he relinquishes his natural ferocity, and is converted into a mean, servile, patient, and parasitical slave.

* 'The individuals known under the name of Albinoes are examples of the same sort of imperfection as that alluded to in the text with regard to animals. They have a skin of a peculiar and unnatural whiteness, white hair, eyebrows, and eyelashes. The iris is also of a rosy tint, and the pupils still more deeply red. This imperfection seems to consist in an entire absence of the colouring principle of all these parts, which leaves the bare texture of the parts themselves without any colour except that of the fluids circulating in them. It occurs among all the varieties of mankind, but more commonly among the dark ones. Stories have been told of whole tribes of Albinoes or white negroes, but they have proved unfounded. Some persons are only partially affected in this way, and thus present a spotted or piebald appearance; and it is to be remarked that if the eyes or any part of the hair be included in any of the spots which remain in the natural state, they retain their natural colour and appearance. The same is the case with inferior animals, as may be frequently observed in the spotted, black and white rabbits. The white rabbit is a true Albino, as is the white mouse, and they both have red eyes, unless the eyes happen to be included in a spot which remains in its natural state.'

CHAPTER XII.

OF THE COVERING, MIGRATION, AND TORPIDITY OF ANIMALS.

'ALTHOUGH man is naturally the most defenceless of animals, and the most exposed to suffer from the attacks of cold and the rigors of inhospitable climates, yet by the sagacity with which he has devised means of guarding against the vicissitudes of the seasons, and protecting himself against the various degrees of heat and cold which he encounters, he has been enabled to brave the dangers of every climate, and establish himself over a great part of the globe. Neither the cold of the polar, nor the heat of the equatorial regions, has been sufficient to deter him; but he is capable of enjoying the necessaries, comforts, and even luxuries of life at either extreme.

'But the constitutions of other animals are not so accommodating. They do not adapt themselves so readily to changes in external circumstances, nor have they the sagacity to avail themselves of other means for protecting themselves from the influence of cold and heat. Each species of animals is generally confined to some particular portion of the earth, and it is with difficulty that many of them are made to survive, for a long time, any great change of climate. To a certain extent, however, nature has provided means for obviating the bad effects which would be produced upon them by the different temperature of the seasons and of different climates. These means are, a change in the quantity or colour of the hair, fur, or feathers, with which they are covered; migration during the winter to warmer climates; or passing it in a state of torpidity.

'In the colder regions of the earth, animals are covered with thick and warm fur. In the warm, they are only clothed with hairs thinly scattered, or have a skin entirely naked. The contrast is more striking where the same kind of animals, or kinds closely resembling each other, inhabit different climates. In the dogs of Guinea, and in the African and Indian sheep, the fur is so thin that they may be almost denominated naked.

In the Siberian dog and Iceland sheep, on the other hand, the body is protected by a thicker and longer covering. In the swine of warm countries, we find a covering of bristles thinly scattered and of a uniform size and texture; but in colder countries, there is, beside this covering, another of fine, frizzled wool next to the skin, through which the bristles project. The elephant of the warm regions has scarcely any hair upon his body, whilst that species which is supposed to be now extinct, but to have formerly inhabited the northern parts of both continents, was clothed with a thick and warm fur; as is proved from the discovery of a carcass which had been preserved in a frozen state, probably for many thousand years, in the ice of Siberia.

'In the same climate the quantity of covering is accommodated to the alterations in the seasons. At the approach of winter the hair is increased in quantity and in length, as may be observed in any of our domestic animals, and this increase is proportioned to the rigour and severity of the season. On the contrary, at the return of the warm season, the fur becomes thin. Hence those animals which are sought, for the sake of their fur, must be hunted in the winter; and it has been observed that, where the beginning of the season is mild and the cold weather late in setting in, the hair is also backward, and that a few days of cold will produce a perceptible change in the rapidity of its growth. The moulting or casting of their plumage in birds furnishes examples to the same point.

'Changes of colour are not so common or so important. But in cold climates there are many striking instances of a complete change from a dark colour to a white, both of fur and of plumage. The summer dress of the Alpine hare is of a tawny grey, but as winter approaches, it changes to a snowy whiteness, continues so until spring, and then resumes its tint of grey. The ermine, which in summer has a fur of a pale reddish brown, exhibits in winter a dazzling white. Among birds a similar change takes place in a great number of species, as in a variety of the smaller kinds known familiarly under the name of snow-birds.

'It is obvious, according to the known laws of the transmission of caloric, how both these provisions concur towards maintaining, during the winter, a proper temperature in the bodies of animals. Animal heat is maintained not by the influence of external causes, but by an internal principle. The object to be attained is, then, to prevent the escape of this heat to other bodies, and preserve it within the system. The increased thickness of the fur effects this purpose by obstructing its gradual transmission to the cold bodies around, and its colour by diminishing the degree of radiation, which is always less from light coloured than from dark substances. Upon the same principle, under ordinary circumstances, the thin covering and dark colour are favourable to the comfort of the animal during summer, since they serve to keep down its temperature by carrying off all superabundant heat, both by gradual communication and by radiation.*

'The second method by which animals avoid the danger and suffering to which they would be exposed by the extremes of climate, is a periodical MIGRATION. In this way they are enabled to live throughout the year in a temperature congenial to their constitution.

'The extensive and numerous migrations of birds have been noticed by mankind from time immemorial. They are accompanied by many circumstances of a curious and interesting nature, and have given rise to a good deal of speculation. The different species of swallow in particular have excited a large share of attention, and the place of their winter residence has been the subject of much doubt.' With regard to the several species of swallows, some naturalists are inclined to think that they do not leave the place of their summer residence at the end of autumn, but that they lie in a torpid state till the beginning of summer in the banks of rivers, the hollows of decayed trees, the recesses of old buildings, the holes of sand-banks, and in similar situations. That swallows, in the winter months, have sometimes, though very rarely, been found in a torpid state, is unquestionably true. Neither is the inference, that,

* 'The uncomfortable sensation of heat in summer arises not *directly* from the external heat, which is seldom so high as that of our bodies, but rather from the animal heat of the system itself, which is prevented by the high temperature of the atmosphere from being carried off as rapidly as usual, and hence becomes, as it were, accumulated. Whatever circumstances, therefore, favour either the radiation or transmission of caloric, will contribute most to comfort; and consequently a dark and thin covering, and one which is a good conductor, would seem to be most proper both for men and for other animals, *under ordinary circumstances.* Where there is exposure, however, to the rays of the sun, the reverse would be true; and this appears at least *not to contradict* experience. If these remarks are well founded, they obviously explain, how the colour of the negro is adapted to the regions he inhabits, by favouring the radiation of heat whenever the temperature of the air is below that of his body. And even in the depths of Africa it is seldom that the thermometer will for any length of time indicate a degree of heat above that of our bodies.'

if any of them can survive the winter in that state, the whole of them may subsist, during the cold season, in the same condition, in the smallest degree unnatural. Still, however, the numbers of swallows which appear in Great Britain, as well as in all parts of Europe, during the summer months, are so very considerable, that, if the great body of them did not migrate to some other climate, they would be much more frequently found in a torpid state. On the contrary, when a few of them are discovered in that state, it is regarded as a wonder even by the country people, who have the greatest opportunities of stumbling upon facts of this kind. When, accordingly, a few swallows or martins are found torpid in winter, and have been revived by a gentle heat, the fact, and few such facts there are, is carefully recorded as singular in all the periodical publications of Europe.

Instances of swallows and some other birds alighting on the masts and cordage of vessels, at considerable distances from any shore, are not so numerous as might be expected. Neither have they been often observed flying over seas in great flocks. Mr Peter Collinson, in a letter printed in the Philosophical Transactions, says, "that Sir Charles Wager had frequently informed him, that, in one of his voyages home in the spring, as he came into soundings in our channel, a great flock of swallows almost covered his rigging; that they were nearly spent and famished, and were only feathers and bones; but, being recruited by a night's rest, they took their flight in the morning."

M. Adanson, in his voyage, informs us, that, about fifty leagues from the coast of Senegal, four swallows settled upon the ship, on the sixth day of October; that these birds were taken; and that he knew them to be the true swallows of Europe, which he conjectures were then returning to the coast of Africa. Mr Barrington,* with more probability, supposes that these swallows, instead of being on their passage from Europe, were only flitting from the Cape de Verde islands to the continent of Africa, a much shorter flight, but to which they seemed to be unequal, as they were obliged, from fatigue, to light upon the ship, and fall into the hands of the sailors.

Swallows, Mr Kalm remarks, appear in the Jerseys about the beginning of April, and are, on the first arrival, wet, because they have just emerged from the sea or lakes, at the

* Essay on the periodical appearing and disappearing of certain birds at different times of year. Phil. Trans. vol. 62.

bottom of which they had remained in a torpid state during the whole winter. But Mr Kalm, who wishes to support the torpidity of swallows during the winter, likewise informs us, that he himself met with them at sea, nine hundred and twenty miles from any land.

These, and similar facts, Mr Barrington endeavours to explain, by supposing that birds discovered in such situations, instead of attempting to cross large branches of the ocean, have been forcibly driven from some coasts by storms, and that they would naturally perch upon the first vessel which came within their view.

In Great Britain, five species of swallows appear in summer and disappear in winter. 1. The house-swallows make their appearance about twenty days earlier than the martin, or any other of the swallow tribe. They are often seen about the 13th day of April. They disappear about the end of September. A few days previous to their departure, they assemble in great flocks on the tops of houses, churches, and trees, from whence they are supposed to take their flight. This unusual and temporary association of numbers indicates the impulse of some common instinct by which each individual is actuated. The house-swallow is easily distinguished from the other species by the superior forkiness of its tail, and by a red spot on the forehead, and under the chin. This species builds in chimneys, and makes its nest of clay, but leaves the top quite open. 2. The martin is inferior in size to the former, and its tail is much less forked. The martins appear in Britain soon after the house-swallow. They build under the eaves of houses. The nest is composed of the same materials as those of the house-swallow; but it is covered above, and a small hole only is left in the side for the ingress and egress of the birds. The martins totally disappear about the beginning of October. 3. The sand-martin, or bank-martin, is by much the smallest of the swallow kind that visit Britain. The sand-martins arrive very soon after the house-swallow, and disappear about Michaelmas. They dig considerable holes in sand-pits and in the banks of rivers, where they build their nests, which consist not of mud, like those of the former species, but of grass and feathers laid together in a very slovenly manner. It is worthy of remark, that these birds do not employ the cavities they dig in summer for winter quarters; since sand-banks, so perforated, have been carefully searched in the winter, and nothing found but empty nests. 4. The swift, or black-martin of Willoughby, is the largest of these swallows, and is the latest of arriving in in the country; for the swifts are seldom seen till the beginning of May, and commonly appear, not in flocks, but in pairs. Swifts, like the sand-martins, carry on the business of incubation in the dark. They build in the crannies of castles, towers, and steeples. Straw and feathers are the materials they use. They disappear very early; for they are almost never seen after the middle of August. 5. The goatsucker, which belongs to the swallow tribe, is likewise a bird of passage. Like the other swallows, it feeds upon winged insects. But, instead of pursuing its prey during the day, it flies only in the night, and seizes moths, and other nocturnal insects. From this circumstance, it has not improperly received the appellation of the *nocturnal swallow*. The goatsucker stays only a short time in Britain. It appears not till about the end of May, and retires in the middle of August. It lays its eggs, which are commonly two and sometimes three, on the bare ground.

Herodotus and Prosper Alpinus mention one species of swallow which resides in Egypt during the whole year; and Mr Loten, late governor of Ceylon, assured Mr Pennant, that those of Java never remove. If these be excepted, all the other known kinds retreat or migrate periodically. Swallows migrate from almost every climate. They remove from Norway, from North America, from Kamtschatka, from the temperate parts of Europe, from Aleppo, and from Jamaica.

Concerning the periodical appearance and disappearance of swallows, there are three opinions adopted by different naturalists. The first and most probable is, that they remove from climate to climate at those particular seasons when winged insects, their natural food, fail in one country or district and abound in another, where they likewise find a temperature of air better suited to their constitutions. In support of this opinion, we have the testimony, as formerly mentioned, of Sir Charles Wager, of M. Adanson, and of many navigators. It is equally true, however, that some species of swallows have been occasionally found in a torpid state during winter. Mr Collinson gives the evidence of three gentlemen who were eyewitnesses to a number of sand-martins being drawn out of a cliff on the Rhine in the month of March 1762. Mr Barrington, in the year 1768, communicated to Mr Pennant, on the authority of the late Lord Belhaven, the following fact; "That numbers of swallows have been found in old dry walls, and in sand-hills, near his Lordship's seat in East-Lothian; not once only, but from year to year; and that, when they were exposed to the warmth of a fire, they revived." These, and other facts of the same kind, seem to be incontrovertible; and Mr Pennant infers from them, that "we must divide our belief relating to these two so different opinions, and conclude, that one part of the swallow tribe migrate. and that others have their winter quarters near home." But we should rather incline to think with those naturalists who suppose that the torpid swallows which are occasionally, though very rarely, discovered in the winter season, have been obliged to remain behind, because they were too young, weak, diseased, or superannuated, to undertake a long and fatiguing flight. Still, however, that the torpidity of the feathered tribes should be solely confined to the swallows, is a very singular fact in the history of nature. Among quadrupeds, there are many species who lie in a dormant or torpid state during winter. But, if the swallow be excepted, not a single species of birds, notwithstanding the great numbers which, at stated times, appear and disappear in every corner of the globe, has ever been discovered in that state. This circumstance alone, though we cannot yet ascertain the precise places to which different species of birds of passage resort, is a most convincing proof of migration in general.

It has been asserted, and even believed, by some naturalists, that swallows pass the winter immersed under the ice, at the bottom of lakes, or beneath the waters of the sea. Olaus Magnus, Archbishop of Upsal, seems to have been the first who adopted this opinion. He informs us, that swallows are found in great clusters at the bottoms of the northern lakes, with mouth to mouth, wing to wing, foot to foot, and that in autumn they creep down the reeds to their subterraneous retreats. "That the good Archbishop," Mr Pennant archly remarks, "did not want credulity in other instances, appears from this, that, after having stocked the bottoms of the lakes with birds, he stores the clouds with mice, which sometimes fall in plentiful showers on Norway and the neighbouring countries!" Klein has endeavoured to support the notion that swallows lie under water during the winter, and gives the following account of their manner of retiring, which he collected from some countrymen. They asserted, he tells us, that the swallows sometimes assembled in numbers on a reed till it broke and sunk them to the bottom; that their immersion was preceded by a kind of dirge, which lasted more than a quarter of an hour; that others united, laid hold of a straw with their bills, and plunged down in society; that others, by clinging together with their feet, formed a large mass, and in this manner committed themselves to the deep.

Two reasons seem to render this supposed submersion of swallows impossible. In the first place, no land animal can exist so long without some degree of respiration. The otter, the seal, and water fowls of all kinds, when confined under the ice, or entangled in nets, soon perish; yet it is well known, that animals of this kind can remain much longer under water than those which are destitute of that peculiar structure of the heart which is necessary for any considerable residence beneath that penetrating element. Mr John Hunter, in a letter to Mr Pennant, informs us, "That he had dissected many swallows, but found nothing in them different from other birds as to the organs of respiration; that all those animals which he had dissected of the class that sleep during winter, such as lizards, frogs, &c. had a very different conformation as to those organs; that all those animals, he believes, do breathe in their torpid state; and, as far as his experience reaches, he knows they do; and that, therefore, he esteems it a very wild opinion, that terrestrial animals can remain any long time under water without drowning." Another argument against their submersion arises from the specific gravity of the animals themselves. Of all birds, the swallow tribes are perhaps the lightest. Their plumage, and the comparative smallness of their weight, indicate that nature destined them to be almost perpetually on the wing in quest of food. From this specific lightness, the submersion of swallows, and their continuing for months under water, amount to a physical impossibility. Even waterfowls, when they wish to dive, are obliged to rise and plunge with considerable exertion, in order to overcome the resistance of the water. Klein's idea of swallows employing reeds and straws as means of submersion is rather ludicrous; for these light substances, instead of being proper instruments for assisting them to reach the bottom, would infallibly contribute to support them on the surface, and prevent the very object of their intention. Besides, admitting the possibility of their reaching the bottom of lakes and seas, and supposing they could exist for several months without respiration, what would be the consequence? The whole would soon be devoured by otters, seals, and fishes of various kinds. Nature is always anxious for the preservation of species. But, if the swallow tribes were destined to remain torpid, during the winter months, at the bottom of lakes and seas, she would act in opposition to her own intentions; for, in a season or two, the whole genus would be annihilated.

Mr White of Selborne has favoured us with the following information concerning the migration of swallows. "If ever I saw," says he, "any thing like actual migration, it was last Michaelmas day, 1768. I was travelling, and out early in the morning; at first there was a vast fog; but, by the time that I was got seven or eight miles from home towards the coast, the sun broke out into a delicate warm day. We were then on a large heath or common, and I could discern, as the mist began to break away, great numbers of swallows clustering on the stinted shrubs and bushes, as if they had roosted there all night. As soon as the air became clear and pleasant, they all were on the wing at once, and, by a placid and easy flight, proceeded on southward towards the sea. After this I did not see any more flocks, only now and then a straggler. When I used to rise in a morning last autumn, and see the swallows and martins clustering on the chimneys and thatch of the neighbouring cottages, I could not help being touched with secret delight, mixed with some degree of mortification; with delight, to observe with how much ardour and punctuality those poor little birds obeyed the strong impulse towards migration, or hiding, imprinted on their minds by their great Creator; and with some degree of mortification, when I reflected, that after all our pains and inquiries, we are yet not quite certain to what regions they do migrate; and are still farther embarrassed to find, that some do not actually migrate at all."

In another part of his work, Mr White says; "But we must not deny migration in general; because migration certainly does subsist in some places, as my brother in Andalusia has fully informed me. Of the motions of these birds he has ocular demonstration, for many weeks together, both spring and fall; during which periods, myriads of the swallow kind traverse the straits from north to south, and from south to north, according to the season. And these vast migrations consist not only of swallows, but of bee-birds, hoopoes, oropendulos or golden-thrushes, &c. &c. and also many of our soft-billed summer birds of passage; and, moreover, of birds which never leave us, such as all the various sorts of hawks and kites. Old Belon, two hundred years ago, gives a curious account of the incredible armies of hawks and kites which he saw in the spring time traversing the Thracian Bosphorus from Asia to Europe. Besides the above mentioned, he remarks that the procession is swelled by whole troops of eagles and vultures."

"The swallow," says Dr Fleming, in his Philosophy of Zoology, "about whose migrations so many idle stories have been propagated and believed, departs from Scotland about the end of September, and from England about the middle of October. In the latter month, M. Adanson observed them on the shores of Africa after their migrations from Europe. He informs us, however, that they do not build their nests in that country, but only come to spend the winter. M. Prelong has not only confirmed the observations of Adanson in reference to swallows, but has stated at the same time, that the yellow and grey wagtails visit Senegal at the beginning of winter. The former (motacilla flava) is well known as one of our summer visitants. The nightingale departs from England about the beginning of October, and from the other parts of Europe about the same period. During the winter season it is found in abundance in lower Egypt, among the thickest coverts, in different parts of the Delta. These birds do not breed in that country, and to the inhabitants are merely winter birds of passage. They arrive in autumn and depart in spring, and at the time of migration are plentiful in the islands of the Archipelago. The quail is another of our summer guests, which has been traced to Africa. A few indeed brave the winters of England, and in Portugal they appear to be stationary. But in general they leave this country in autumn and return in spring. They migrate about the same time from the eastern parts of the continent of Europe, and visit and revisit in their migrations the shores of the Mediterranean, Sicily, and the islands of the Archipelago."

'Beside those birds which retire in the winter from temperate to more southern climates, there are many others which spend the summer in the northern regions, and seek a milder residence during the winter in the same countries from which the former have migrated. Thus in every country or district a double migration takes place. There are two sets of birds, one which frequents it in the summer and another in the winter. The former are called summer birds of passage, the latter winter birds of passage. The summer residence of the birds of passage, which frequent temperate climates in the winter, is not always known, but many of them have been traced to northern countries. The snow-buntings, which are common in Great Britain during the winter, retreat in the summer to the polar regions of Spitzbergen, Lapland, and Greenland, where they pair and produce their offspring.' Martin, in his history of the Hebrides, or Western Isles, informs us, that wild swans arrive in great numbers in Lingey, one of the Hebrides, in the month of October, and remain there till March, when they retire more northward to breed. For this purpose, the swans, like most other waterfowls, prefer such places as are least frequented by mankind. During summer, the lakes, marshes, and forests of Lapland are filled with myriads of waterfowls. In that northern region, swans, geese, the duck-tribe, goosanders, divers, &c. pass the summer; but in autumn they return to more hospitable shores.

The wild goose, which breeds in the most retired regions of the North, arrives in temperate regions, at the beginning of winter, and departs early in the spring. Their periodical movements are familiar to all. They fly at a great height, and observe the utmost regularity in all their movements. Many birds of the duck kind are also winter birds of passage. They are found in abundance upon the shores, islands, and rivers of the temperate regions during the cold months; but, on the approach of winter, migrate to Lapland, Greenland, and Spitzbergen.

The solan geese, or gannets, are birds of passage, which pass their summer and breed upon the most northern shores and islands of Scotland. The multitudes which frequent these places are prodigious. "There is," says a writer who has given some account of them, "a small island in the Frith of Forth, called the Bass Island, which does not exceed a mile in circumference. The surface of this island, during the months of May and June, is so entirely covered with nests, eggs, and young birds, that it is scarcely possible to walk without treading on them. The flocks of birds on the wing are so prodigious, that they darken the air like clouds, and their noise is so great, that a man cannot without difficulty hear his neighbour's voice. If, from the top of the precipice, you look down upon the sea, you will see it on every side covered with infinite numbers of birds of different kinds, swimming about and hunting for their prey. When sailing round the island, if you survey the hanging cliffs, you will perceive, in every cragg, or fissure of the rocks, innumerable birds of various kinds, more than the stars of heaven in a serene night. If you view the distant flocks, either flying to or from the island, you will imagine them to be a vast swarm of bees." The rocks of St Kilda seem to be equally frequented by solan geese; for Martin, in his description of the Hebrides, informs us, that the inhabitants of this small island consume annually no less than 22,600 young birds of this species, beside an amazing number of their eggs. The solan geese and their eggs constitute the chief food of these islanders. They preserve both the fowls and the eggs in small pyramidal stone buildings, which, to protect the food from moisture, they cover with the ashes of turf. The solan geese are birds of passage. Their first appearance is in March, and they continue till August or September. But, in general, the times of their breeding and departure seem to coincide with the arrival of the herring, and the migration of that fish from our coasts. It is more than probable that these birds attend the herrings and pilchards during their whole circuit round the British islands; for the appearance of the solan geese is always esteemed by the fishermen as a certain presage of the approach of the herrings or pilchards. In quest of food, these birds migrate as far south as the mouth of the Tagus; for they are frequently seen off Lisbon during the month of December.

The various species of curlews, woodcocks, sandpipers, and plovers, which pass the winter in Great Britain, retire in the spring to Sweden, Poland, Prussia, Norway, and Lapland, both to feed and to breed. They return as soon as the young are able to fly; because the frosts, which set in early in these countries, totally deprive them of the means of subsistence. For the same reason they take their departure in summer, as the dryness and hardness of the ground prevent them from penetrating the earth with their bills in quest of worms, which constitute their natural food.

From the facts which have been enumerated, and from others of a similar nature, it is evident, that many birds, both of the land and water kinds, migrate from one climate to another. But, even in the same climate and country, birds occasionally perform partial migrations. During hard winters, when the surface of the earth is covered with snow, many birds, as larks, snipes, &c. retire from the inland parts of the country to the seashores, where they pick up a scanty subsistence. Others, as the wren, the redbreast, and many of the small birds, or sparrow kind, resort to gardens, and the habitations of men. Their intention, it is obvious, is to procure food and shelter.

There are three principal objects of migration; food, temperature of air, and convenient situations for breeding. Such birds as migrate to great distances are alone denominated *birds of passage*. But all birds are, in some measure, birds of passage, though they do not migrate to places so remote from their former abodes. At particular times of the year, most birds migrate from one country to another, or from the more inland districts toward the shores. These partial migrations of small birds are well known to birdcatchers, who make a livelihood by ensnaring them into their nets, and selling them. The birds *fly*, as the birdcatchers term it, about the end of September, and during the months of October and November. There is another, but less considerable, flight in March. Some begin their flight annually about Michaelmas; others, as the woodlarks, succeed, and continue their flight till the middle of October; but the greenfinch does not migrate till the frost obliges it to remove in quest of food and shelter. These partial migrations, or flittings, are performed from day break till noon. Another, but smaller, flight commences at two o'clock and continues till night approaches. The times when particular birds migrate from one situation to another are well known to the birdcatchers, who, by means of call-birds, nets, and other devices, seize great numbers of them, and, after accustoming them for some time to restraint and slavery, sell them for considerable prices, to curious men and whimsical women. A diligent attention to these partial migrations, and their motives, would soon unfold the causes of those of a more extensive kind.

'Migrating birds before they take their departure in general collect together in flocks, and many of them are known to perform their migrations in company and to form large and regularly arranged flocks on their route. Swallows are well known to assemble in immense numbers before the period of their migration. Some birds, however, have never been observed to gather together previous to their departure. The males of many species appear to perform their migrations a few days before the females. This is remarkably the case with the nightingale. Others depart during the night. In short, the habits of birds with regard to their migrations differ according to their characters and habits in other respects.

'It has been objected to the migration of birds, that it is impossible they should support themselves so long upon the wing or exist so long without food, as they must probably do in performing such long journies as migration supposes. "But these difficulties," says Dr Fleming, "vanish altogether when we attend to the rapidity of the flight of birds. The rapidity with which a hawk and many other birds occasionally fly, is probably not less than at the rate of 150 miles an hour. Major Cartwright, on the coast of Labrador, found by repeated observations, that the flight of an eider duck, was at the rate of 90 miles an hour. Sir George Cayley computes the rate of flight, even of the common crow, at nearly 25 miles an hour; and Spallanzani found that of the swallow completed about 92 miles, while he conjectures that the rapidity of the swift is nearly three times greater. A falcon, which belonged to Henry IV of France, escaped from Fontainbleau, and in 24 hours was found at Malta, a distance of 1350 miles; a velocity nearly equal to 57 miles an hour, supposing the falcon to have been upon the wing the whole time. But as such birds never fly by night, and allowing the day to be at the longest, his flight was perhaps equal to 75 miles an hour. It is probable, however, that he neither had so many hours of light in the twenty-four, to perform his journey, nor that he was retaken the moment of his arrival. But if we even restrict the migratory flight of birds to the rate of 50 miles an hour, how easily can they perform their most extensive migrations! and we know, in the case of woodcocks, and perhaps all other migrating birds, that they in general take advantage of a fair wind with which to perform their flights. This breeze perhaps aids them at the rate of 30 or 40 miles an hour; nay, with three times greater rapidity, even in a moderate breeze, if we are to give credit to the statement of aerial navigators, who seem to consider the rate of the motion of winds as in general stated too low." If this be true, the movements of birds in their migrations may be performed with little difficulty; for even those that execute their journeys at one flight, if there be any that do so, may do it in a very short time, perhaps a day, by the help of a favourable wind.'

Migration is often supposed to be peculiar to the feathered tribes. This is a limited idea, which has originated from inattention to the economy of nature. Birds migrate with a view to remedy the inconveniences of their present situation, and to acquire a more commodious station with regard to food, temperature, generation, and shelter. From similar motives, men, sometimes in amazing multitudes, have migrated from north to south, displaced the native inhabitants, and fixed establishments in more comfortable climates than those which they had relinquished. These, in their turn, have fallen victims to fresh and barbarous emigrants. Among the inhabitants of the more northern nations, as Norway, Sweden, Scotland, &c. notwithstanding a very strong attachment to their native countries, there seems to be a natural or instinctive propensity to migrate. Poverty, the rigour of the climate, curiosity, ambition, the false representations of interested individuals, the oppression of feudal barons, and similar circumstances, have given rise to great emigrations of the human species. But it is worthy of remark, that the emigrations from south to north, except from the love of conquest in ambitious nations, are so rare, that the instinct seems hardly to exist in those more fortunate climates. Curiosity is a general instinctive principle, which operates strongly in the youthful periods of life, and stimulates every man to visit places that are distant from his ordinary residence. This innate desire is influenced by the relations of travellers, and by many other incentives of a more interested kind. Without the principle of migration, mankind, it is probable, would never have been so universally diffused over the surface of the earth. It is counterbalanced, however, by attachment to those countries which gave us birth, a principle still more powerful and efficient. Love of our native country is so strong, that, after gratifying the migrating principle, almost every man feels a longing desire to return.

Savages, as long as their store of food remains unexhausted, continue in a listless, inactive state. They exhaust many days sitting in perfect indolence, and seem not to be prompted by any motives of curiosity. They have not a conception of a man's walking either for amusement or exercise. But, when their provisions begin to fail, an astonishing reverse takes place. They then rouse as from a profound sleep. In quest of wild beasts, birds, and fishes, they migrate to immense distances, exert the greatest feats of activity, and undergo incredible hardships and fatigue. After acquiring a store of provisions, they return to their wonted haunts, and remain inactive till their food again begins to fail.

'There are but few quadrupeds which perform migrations, and these are generally limited in their extent to different parts of the same country. A few species, however, which have faculties for more extensive locomotion, perform more extensive migrations. Thus some of the bats of England spend their winters in Italy in a torpid state, and the seal, which frequents the shores of Greenland during the summer, removes at the approach of cold weather to the south, and spends the winter in the neighbourhood of Iceland.'

At the approach of winter, the stag, the rein-deer, and the roebuck, leave the tops of the lofty mountains, and come down to the plains and copses. Their chief objects, in these flittings, are food and shelter. When summer commences, they are harassed with different species of winged insects, and, to avoid these enemies, they regain the summits of the mountains, where the cold and the height of the situation protect them from the attacks of the flies. In Norway, and the more northern regions of Europe, the oxen, during the winter, migrate to the shores of the sea, where they feed upon sea plants and the bones of fishes; and Pontoppidan remarks, that the cattle know by instinct when the tide retires, and leave these articles of food upon the shore. In Orkney and Shetland, the sheep, in winter, for the same purposes, uniformly repair to the shore at the ebbing of the tides. Rats, particularly those of the northern regions of Europe, appear, from time to time, in such myriads, that the inhabitants of Norway and Lapland imagine the animals fall from heaven. The celebrated Linnæus, who paid great attention to the economy of these migrating rats, remarked, that they appeared in Sweden periodically, every eighteen or twenty years. When about to migrate, they leave their wonted abodes, and assemble together in numbers inconceivable. In the course of their journey, they make tracks in the earth, of two inches in depth; and these tracks sometimes occupy a breadth of several fathoms. What is singular, the rats, in their march, uniformly pursue a straight line, unless they are forced to turn aside by some unsurmountable obstacle. If they meet with a rock, they first try to pierce it, and, after discovering the attempt to be impracticable, they go round it, and then resume the straight line. Even a lake does not interrupt their passage; for they either traverse it in a straight line, or perish in the attempt; and, if they meet with a bark or other vessel, they do not alter their direction, but climb up the one side of it, and descend by the other.

Frogs immediately after their transformation from the tadpole state, leave the water, and migrate to the meadow or marshy grounds in quest of insects. The number of young frogs, which suddenly make their appearance in the plains, induced Rondeletius, and many other naturalists, to imagine that they were generated in the clouds and showered down upon the earth. But if, like the worthy and intelligent Dr Derham, they had examined the situation of the place with regard to stagnating waters, and attended to the nature and transformation of the animals, they would soon have discovered the real cause of the phenomenon.

Of all migrating animals, particular kinds of fishes make the longest journeys, and in the greatest numbers. The multiplication of the species, and the procuring of food, are the principal motives of the migration of fishes. The salmon, a fish which makes regular migrations, frequents the northern regions alone. It is unknown in the Mediterranean sea, and in the rivers which fall into it both from Europe and Africa. It is found in some of the rivers of France that empty themselves into the ocean. Salmons are taken in the rivers of Kamtschatka, and appear as far north as Greenland. They are found in many of the rivers of the United States, and ascend and descend the river Columbia in immense and almost incredible shoals. The Indians around this river preserve them in a dried state and make them a principle article of food. Salmons live both in the ocean and in fresh waters. For the purpose of depositing their spawn, they quit the sea in the month of September, and ascend the rivers. So strong is the instinct of migrating, that they press up the rivers with amazing keenness, and scarcely any obstacle is sufficient to interrupt their progress. They spring, with great agility, over cataracts of several feet in height. In their leaps, they spring straight up with a strong tremulous motion, and do not, as has been vulgarly supposed, put their tails in their mouths. When they find a place which they think proper for depositing their eggs, the male and female unite their labours in forming a convenient receptacle for the spawn in the sand, which is generally about eighteen inches deep. The eggs, when not disturbed by violent floods, lie buried in the sand till the spring, and they are hatched about the end of March. The parents, however, after this important office has been performed, hasten back to the sea. Toward the end of March, the young fry begin to appear, and they gradually increase in size till they acquire the length of four or five inches. About the beginning of May, all the considerable rivers of Scotland are full of salmon fry. After this period, they migrate to the sea. About the middle of June, the earliest of the fry begin to appear again in the rivers. At that time they are from twelve to sixteen inches long, and gradually augment, both in number and size, till about the end of July or the beginning of August, when they weigh from six to nine pounds. This is a very rapid growth. But a gentleman of credit at Warrington informed Mr Pennant of a growth still more rapid. A salmon, weighing seven pounds and three quarters, was taken on the seventh day of February. It was marked on the back, fin, and tail, with scissars, and then turned into the river. It was retaken on the 17th day of the following month of March, and then it weighed seventeen pounds and a half. The season for fishing salmon in the Tweed begins on the 30th of November, and ends on old Michaelmas day. In that single river, it is computed that no less than 208,000 at a medium, are annually caught, which, together with the products of many other rivers on both sides of Scotland, not only afford a wholesome and palatable food to the inhabitants, but form no inconsiderable article of commerce.

Herrings are likewise actuated by the migrating principle. These fishes are chiefly confined to the northern and temperate regions of the globe. They frequent the highest latitudes, and are sometimes found on the northern coasts of France. They appear in vast shoals on the coast of America, as far south as Carolina. In Chesapeak Bay there is an annual inundation of herring; and Mr Catesby informs us, that they cover the shores in such amazing numbers as to become offensive to the inhabitants. The great winter rendezvous of the herrings is within, or near, the Arctic Circle, where they remain several months, and acquire strength after being weakened by the fatigues of spawning, and of a long migration. In these seas, food is much more abundant than in warmer latitudes. They begin their migration southward in the spring, and appear off the Shetland islands in the months of April and May. These, however, are only the forerunners of the immense shoal which arrives in June. Their approach is recognised by particular signs, such as the appearance of certain fishes, the vast number of birds, as gannets or solan geese, which follow the shoal to prey upon the herrings. But, when the main body arrives, its breadth and depth are so great as to change the appearance of the ocean itself. The shoal is generally divided into columns of five or six miles in length, and three or four in breadth. Their progressive motion creates a kind of rippling or small undulations in the water. They sometimes sink and disappear for ten or fifteen minutes, and then rise again toward the surface. When the sun shines, a variety of splendid and beautiful colours are reflected from their bodies. In their progress southward, the first interruption they meet with is from the Shetland islands. Here the shoal divides into two branches. One branch skirts the eastern, and the other the western shores of Great Britain, and fill every bay and creek with their numbers. Those which proceed to the west from Shetland, after visiting the Hebrides, where the great fishery is carried on, move on till they are again interrupted by the north of Ireland, which obliges them to divide a second time. One division takes to the west, where they are scarcely perceived, being soon lost in the immensity of the Atlantic Ocean. The other division goes into the Irish Sea, and affords nourishment to many thousands of the human race. The chief object of herrings migrating southward is to deposit their spawn in warmer and more shallow seas than those of the frigid zone. This instinct seems not to be prompted by a scarcity of food ; for, when they arrive upon our coasts, they are fat and in fine condition ; but when returning to the ocean, they are weak and emaciated. They continue in perfection from the end of June to the beginning of winter, when they begin to deposit their spawn. The great stations of the herring fisheries are off the Shetland and the Western islands, and along the coast of Norfolk.

Beside salmons and herrings, there are many fishes which observe a regular migration, as mackerels, lampreys, pilchards, &c. About the middle of July, the pilchards, which are a species of herrings, though smaller, appear in vasts shoals off the coasts of Cornwall. When winter approaches, like the herrings, they retire to the Arctic seas. Though so nearly allied to the herring, it is not incurious to remark, that the pilchards, in their migration for the purpose of spawning, choose a warmer latitude.

Of the land-crab there are several species. The migration of what is called the violet land-crab deserves some notice. It inhabits the warmer regions of Europe, but its particular residence is in the tropical climates of Africa and America. Land-crabs generally frequent the mountainous parts of the country, which are of course, most remote from the sea. They inhabit the hollows of old trees, the clefts of rocks, and holes which they themselves dig in the earth, They are extremely numerous. In the months of April and May, they leave their retreats in the mountains, and march in millions to the seashore. At this period the whole ground is covered with them, and a man can hardly put down his foot without treading on them. The object of their migration is to deposit their spawn on the seashore. In their progress toward the sea, like the northern rats, the land-crabs move in a straight line. Even when a house intervenes, instead of deviating to the right or left, they attempt to scale the walls. But, when they meet with a river, they are obliged to wind along the course of the stream. In their migration from the mountains, they observe the greatest regularity, and commonly divide into three battalions, or bodies. The first consists of the strongest and boldest males, who, like pioneers, march forward to clear the route, and to face the greatest dangers. The females, who form the main body, descend from the mountains in regular columns, which are fifty paces broad, three miles long, and so close that they almost entirely cover the ground. Three or four days afterwards, the rearguard follows, which consists of a straggling, undisciplined troop of males and females. They travel chiefly during the night; but, if it rains by day (for moisture facilitates their motion), they proceed in their slow, uniform manner. When the sun shines, and the surface of the ground is dry, they make a universal halt till evening, and then resume their march. When alarmed with danger, they run backward in a disorderly manner, and hold up their nippers in a threatening posture. They even seem to intimidate their enemies; for, when disturbed, they make a clattering noise with their nippers. But, though they endeavour to render themselves formidable to their enemies, they are cruel to each other. When an individual, by any accident, is so maimed that he cannot proceed, his companions immediately devour him, and then pursue their journey. After a fatiguing and tedious march, which sometimes continues three months before they reach the shore, they prepare themselves for depositing their spawn. The eggs still remain in the bodies of the animals, and are not excluded, as usual to this genus, under the tail. To facilitate the maturation and exclusion of the eggs, the land-crabs no sooner arrive on the shore, than they approach to the margin of the sea, and allow the waves to pass several times over their bodies. They immediately retire to the land; the eggs, in the mean time, come nearer to maturity, and the animals once more go into the water, deposit their eggs, and leave the event to nature. The bunches of spawn are sometimes as large as a hen's egg; and it is not incurious to remark that, at this very period, numbers of fishes of different kinds are anxiously waiting for this annual supply of food. Whether the painful migration of the land-crabs, or the wonderful instinct of the fishes which await their arrival, in order to devour their spawn, is the most astonishing fact, we shall leave to the consideration of philosophers. The eggs which escape these voracious fishes are hatched under the sand. Soon after, millions of minute crabs are seen leaving the shore, and migrating slowly toward the mountains. Most of the old ones, however, remain in the flat parts of the country till they regain their strength. They dig holes in the earth, the mouths of which they cover with leaves and mud. Here they throw off their old shells, remain quite naked, and almost without motion for six days, when they become so fat that they are esteemed delicious food. When the new shell has hardened, the animals, by an instinctive impulse, march back to those mountains which they had formerly deserted. In Jamaica, where they are numerous, the land-crabs are regarded as great delicacies; and they are so abundant, that the slaves are often fed entirely upon them.

The migrating principle is not confined to men, quadrupeds, birds, and reptiles; it extends to many of the insect tribes. Numberless inhabitants of the air pass the first stages of their existence in the water. There they remain for longer or shorter periods, according to the species. Previous to their transformation into chrysalids, they quit the water, and come upon dry ground, where they undergo their amazing change. Instead of being active water-worms, they dig or find holes in the earth, where they are converted into chrysalids, or seemingly inanimate beings, and in a short time, mount into the air in the form of winged insects. Similar migrations are to be observed among land insects. But migration is not confined to water-worms. Many species of caterpillars, which feed upon the leaves of trees, shrubs, and other vegetables, when about to undergo their transformation, leave their former abodes, descend from the trees, and conceal themselves in the earth. The hiving of bees, when numerous colonies remove in order to establish new settlements, is another instance of the migration of insects. Indeed, if we except bees, wasps, ants, and a few others, most insects, whether they inhabit the air, the earth, or the waters, are perfect wanderers, having no fixed place of residence. Some of them, as the spider tribes, build temporary apartments; but when disturbed, they migrate to another commodious place, and erect new habitations.

From the facts which have been enumerated, it is apparent, that the principle of migration, or the desire of changing situations, is not confined to particular birds, but extends through almost the whole system of animation. Men, quadrupeds, birds, fishes, reptiles, insects, all afford striking examples of the migrating principle. From the same facts it is equally apparent, that the general motives for migrating are similar in every class of animals. Food, multiplication of the species, and a comfortable temperature of air, are evidently the chief causes which induce animals to remove from one place to another, or, what amounts to the same thing, from one climate to another. Partial emigrations, or emigrations to small distances, are prompted by the same instinctive motives which induce animals of a different structure to undertake long and fatiguing excursions. But, previous to actual migration, what are the peculiar feelings of different animals, and what should stimulate them to proceed uniformly in the direction that ultimately leads them to the situations most accommodated to their wants and their constitutions, are mysteries, with regard to which, like every other part of the economy of nature, it is the duty of philosophers, instead of attempting to push their inquiries beyond the bounds of human ability, to observe a respectful silence.

'The third method by which animals are enabled to avoid suffering from the winters of cold climates, is by passing them in a state of TORPIDITY. Among quadrupeds, those which become torpid are found in the orders Carnivora and Rodentia; as the bat, hedge-hog, tenrec, marmot, hamster, dormouse, &c. They pass into the state of torpidity at different times of the year according to the severity of the climate they inhabit. Thus in Canada the jerboa goes into winter quarters in September and comes out in May, but in England torpid animals usually retire in October and reappear in April. The place in which they pass the winter, is that which they have been accustomed to inhabit during the summer. The bats retire to caves and old chimneys, where they remain suspended by the claws. The marmot, hamster, &c. secure themselves in their subterranean retreats, and when they first feel the approach of the torpid state, shut the passages to their habitations, in such a manner, that it is more easy to dig up the earth any where else than in the parts they have thus fortified. At the time of becoming torpid, animals are generally very fat; this fat during the winter, is absorbed for the purpose of nutrition, and they become quite lean.

'During the torpid state, the temperature becomes very much diminished. The natural heat of these animals is generally a little above that of man, but during torpidity it descends to 30° or 40° of Fahrenheit, as has been ascertained by accurate observation, but still, generally continues above that of the surrounding atmosphere. The quantity of respiration is also very much lessened. The animal has long intervals of complete repose, during which it does not breathe at all, and then performs a number of respirations in immediate succession. Sometimes this function is for a considerable time entirely suspended, and the degree in which it is diminished, is in proportion to the more or less complete state of torpidity of the animal.

'Connected with this diminution of temperature and respiration, there is a corresponding diminution in the force and rapidity of the circulation. The heart beats feebly and with less force. In the hamster, whose pulse, in its active state, amounts to 150 in a minute, it is, when the animal is torpid, reduced to only 15 in the same period. The pulsations of the heart in dormice, under common circumstances, from their great frequency, can scarcely be counted; but as soon as they begin to pass into the torpid state, the pulse is reduced gradually to thirty, twenty, and sixteen, and becomes finally imperceptible from feebleness. Whilst this lethargy continues, these animals remain entirely insensible to external objects. They do not feel when wounded, or deprived of their limbs; they are not roused by the electric spark. The functions of the digestive organs cease, and they are not only without the appetite for food, but without the power of digesting it. The stomach and bowels are found empty and collapsed. There seems to be only just so much of vital action going on in the system, as is sufficient to keep the spark of life from becoming entirely extinguished.

'Torpidity is brought on by the first cold weather in the autumn, and is probably principally produced by cold. Torpid animals, however, sometimes revive a little, during the warm days which occur during the winter, and in this case they take some food. It is remarkable, that although the ordinary cold of the season keeps them in the torpid state, yet exposure to a much lower temperature than that to which they are commonly subjected, rouses them from it. Thus a marmot which had remained in its natural lethargic state in an atmosphere of 45°, upon being exposed to one of 16°, soon gave signs of returning animation and in sixteen hours was completely revived; it shivered with cold and made attempts to escape. The same has been found true of bats. If this diminished temperature be continued, the animal is frozen to death. The benevolent object of this singular provision is obvious. It prevents the destruction of life which might arise from the occurrence of uncommonly cold weather, or from the accidental exposure of the habitations of torpid animals to the access of cold, by rousing them from their lethargy and enabling them to seek protection from the danger which threatens them.

'Animals come out of their torpid state diminished in weight, but not with any considerable diminution in strength, or vigour of constitution. They enter immediately with great alacrity upon the business of the season, the collection of food, and preparation for the reception of their young. It is not improbable that this winter lethargy acts in some measure like sleep, in refreshing and invigorating the system, and may be necessary to the constitutions of some animals.

'It has been frequently supposed, that many birds, as well as quadrupeds, become torpid during the winter, and instances have been related in particular of swallows which have been found at the bottom of ponds, or rivers, and have revived on exposure to air and warmth. That birds have been sometimes found in a torpid state is highly probable, but the facts which have come to light are not sufficient to authorize the belief, that any species pass the winter in a torpid state as a substitute for the annual migrations by which they are usually enabled to avoid the extremes of cold.

'All the reptiles of cold climates become torpid during the winter, and the phenomena they exhibit do not differ essentially from those of quadrupeds. Below the temperature of 50° they soon fall into a state of lethargy, which continues till spring; and by exposing them in an ice-house, where the atmosphere remains constantly below that degree of heat, reptiles have been kept in a torpid state for three years and a half, and have at the end of that time readily revived. No limits can be set to the time during which they might thus be kept in a dormant state, without the extinction of life, and this fact seems to account, in some measure, for the finding of toads imbedded in stone.

'Many animals of the lower classes are also capable of becoming torpid. Several of the mollusca, spiders, the house-fly, the cricket, &c. are known under favourable circumstances to pass the winter in a torpid state and revive in the spring.

'In these different ways, then, different animals are enabled to avoid the dangers to which they are exposed from the varying temperature of the seasons; 1st. By a change in the quantity and colour of their covering; 2dly. By periodical migrations; and 3dly. By passing the winter in a lethargic state.'

CHAPTER XIII.

OF THE LONGEVITY AND DISSOLUTION OF ORGANIZED BODIES.

It is a law of nature, though a melancholy one, that all organized bodies should be dissolved. The periods of dissolution, however, are as various as the species, and the intentions of nature in producing them.

In the human kind, the brevity of life is regarded as an object of regret. One half of mankind die before they arrive at eight years of age. From that early period to eighty, beside the destruction of war, and other accidents, nature kills them annually in millions. Some instances may be given of men whose lives were prolonged beyond the usual period of human existence. Such men are not to be envied; nor should they be considered as favourites of nature. With respect to maturity of judgment, and a knowledge of the world, no man can be said to exist till he passes thirty years of age. Give him thirty or thirty-five more, and. in general, both mind and body are visibly declined. Those people, therefore, who arrive at an extraordinary age, may be said to exist, but they do not live. All intellectual enjoyments and exertions, which constitute the chief dignity and happiness of man, a:e gone. There are exceptions; but these exceptions are confirmations of what we have advanced. Mankind in the early ages of the world, have been said to live for several centuries. We mean not to contradict the assertion. But we must remark, that, if ever men lived so long, they must have been very different, both in the structure of their bodies, and in their manners, from those who now exist. From infancy to manhood, there is a gradual growth or extension of our organs. After this period, and when we advance in years, the bones harden, the muscles become stiff, the cartilages are converted into bones, the membranes into cartilages, the stomach and bowels lose their tone, and the whole fabric, instead of being soft, flexible, and obedient to the inclinations, or even the commands, of the mind, becomes rigid, inactive, and feeble. These are the general and progressive causes of death, and they are common to all animals. There are modes of living more favourable to health, than others. But examples are not wanting of men who have arrived at an extreme old age, without observing either temperance, or any of the other modes of living which are generally supposed to be favourable to longevity. Some men, who lived temperately, and even abstemiously, reached to great ages; others, who observed the very opposite conduct, who lived freely and often intemperately, have had their existence equally prolonged. But, in general, notwithstanding a few exceptions, temperance, a placid and cheerful disposition, moderate exercise, and proper exertions of mind, contribute, in no uncommon degree, to the prolongation of life.

A few examples of longevity in the human species, though no general conclusions can be drawn from them, may not be incurious to the reader. We shall not go back to a remote and obscure antiquity, but confine ourselves to more modern times, when the modes of living were nearly the same as they are at present.

On this subject, the celebrated Lord Verulam, in his Sylva Sylvarum, gives the following passage, chiefly translated from the seventh book of Pliny's Natural History. "The year of our Lord seventy-six, falling into the time of Vespasian, is memorable; in which we shall find, as it were, a kalendar of long-lived men; for that year there was a taxing (now a taxing is the most authentical and truest informer touching the ages of men), and in that part of Italy which lieth between the Apennine mountains and the river Po, there were found 124 persons that either equalled or exceeded an hundred years of age, namely,

Fifty-four - - - -	of 100 years each.
Fifty-seven - - - - -	110
Two - - - - - -	125
Four - - - - -	130
Four - - - - - -	135 or 137
Three - - - - -	140

Beside these, Parma, in particular, afforded five, whereof

Three were - - - -	120 years each
Two - - - - -	130
One in Bruxelles - - -	125
One in Placentia - - -	131
One in Faventia - - -	132

A certain town, then called the Velleiatium, situate in the hills about Placentia, afforded ten, whereof

Six were - - - - -	110 years each
Four - - - - - -	120
One in Rimino, whose name was Marcus Aponius - - -	150."

The most extraordinary instance of longevity in Great Britain, was exhibited in the person of Henry Jenkins. He was a native of Yorkshire, lived to the amazing age of 169 years, and died on the 8th day of December 1670.

Next to Jenkins, we have the famous Thomas Parre, who was a native of Shropshire, and died on the 16th day of November 1635, at the age of 152.

Francis Consist, a native of Yorkshire, aged 150, died in January 1768.

Margaret Foster, aged 136, and her daughter, aged 104, were natives of Cumberland, and both alive in the year 1771.

William Evans, aged 145, lived in Caernarvon, and still existed in the year 1782.

Dumiter Radaloy, aged 140, lived in Harmenstead, and died on the 16th day of January 1782.

James Bowels, aged 152, lived in Killingworth, and died on the 15th day of August 1656.

The Countess of Desmond, in Ireland, saw her 140th year.

Mr Ecleston, a native of Ireland, lived to the age of 143, and died in the year 1691.

John Mount, a native of Scotland, saw his 136th year, and died on the 27th day of February 1776.

William Ellis of Liverpool died on the 16th day of August 1780, at the age of 130.

Colonel Thomas Winsloe, a native of Ireland, aged 146, died on the 22d day of August 1766.

John Taylor was born in Carrygill, in the county of Cumberland. He was bred a miner. His father died when John was only four years of age. Poverty obliged him to be set early to work. During two years he dressed lead ore for 2d. a day. The next three or four years he assisted the miners in removing the ore and rubbish to the bank, for which he received 4d. a day. At this period there happened a great solar eclipse, which was distinguished in Scotland by the appellation of Mirk Monday.* This event, which he always repeated with the same circumstances, is the chief era from which John's age has been computed. After labouring many years both in this and the neighbouring kingdom, he died, near Lead-hills in Scotland, in the month of May 1770, at the great age of 133.

'An account is given by Professor Silliman, in his Journal of a Tour to Quebec, of a visit which he paid near Whitehall, in the state of New York, to a man who had reached the extreme age of one hundred and thirty four years. His name was Henry Francisco, and he was a native of France. "He believes himself to be 134 years old, and the country around believe him to be of this great age. When we arrived at his residence, (a plain farmer's house, not painted, rather out of repair, and much open to the wind,) he was up stairs, at his daily work, of spooling and winding yarn. This occupation is auxiliary to that of his wife, who is a weaver, and although more than eighty years old, she weaves six yards a day, and the old man can supply her with more yarn than she can weave. Supposing he must be very feeble, we offered to go up stairs to him, but he soon came down, walking somewhat stooping, and supported by a staff, but with less apparent inconvenience, than most persons exhibit at 85 or 90. His stature is of the middle size, and although his person is rather delicate and slender, he stoops but little, even when unsupported. His complexion is very fair and delicate, and his expression bright, cheerful, and intelligent; his features are handsome, and considering that they have endured through one third part of a second century, they are regular, comely, and wonderfully undisfigured by the hand of time; his eyes are of a lively blue; his profile is Grecian and very fine; his

* *Mirk*, in the Scottish dialect, signifies *dark*; and the eclipse happened in the year 1652. S.

head is completely covered with the most beautiful and delicate white locks imaginable; they are so long and abundant as to fall gracefully from the crown of his head, parting regularly from a central point, and reaching down to his shoulders; his hair is perfectly snow white, except where it is thick in his neck; when parted there, it shows some few dark shades, the remnants of a former century. He still retains the front teeth of his upper jaw; his mouth is not fallen in, like that of old people generally, and his lips particularly, are like those of middle life; his voice is strong and sweet-toned, although a little tremulous; his hearing very little impaired, so that a voice of usual strength, with distinct articulation, enables him to understand; his eyesight is sufficient for his work, and he distinguishes large print, such as the title page of the Bible, without glasses; his health is good, and has always been so, except that he has now a cough and expectoration."

'It appeared from his account of himself, which was consistent and intelligible, and confirmed by collateral historical facts, that his father was a French protestant who fled from France, in the latter part of the reign of Louis XIV, in consequence of the persecutions arising from the revocation of the edict of Nantz, that he took refuge in Holland, and afterwards in England; that Francisco himself was born in the year 1686; that he recollects his emigration from France in 1691, and the coronation of Queen Anne in 1702, at which time he says he was 16 years old. He fought in all Queen Anne's wars, and exhibits the scars of many wounds, but only recollects the name of the Duke of Marlborough, among the commanders under whom he served. He came out with his father to New York early in the last century, though he cannot remember the date, and was engaged in most of the wars which occurred until that of the revolution. "He has had two wives and 21 children; the youngest child is the daughter in whose house he lives, and she is 52 years old; of course he was 82 when she was born." "He has been all his life, a very active and energetic, although not a stout-framed man. He was formerly fond of spirits, and did, for a certain period, drink more than was proper, but that habit appears to have been long abandoned. In other respects he has been remarkably abstemious, eating but little, and particularly abstaining, almost entirely, from animal food; his favourite articles being tea, bread and butter, and baked apples. His wife said that after such a breakfast, he would go out and work till noon; then dine upon the same if he could get it, and then take the same at night; and particularly, that he always drank tea, whenever he could obtain it, three cups at a time, three times a day." "The oldest people in the vicinity, remember Francisco, as being always, from their earliest recollection, much older than themselves; and a Mr Fuller, who recently died here, between 80 and 90 years of age, thought Francisco was one hundred and forty." "He is really a most remarkable and interesting old man; there is nothing, either in his person or dress, of the negligence and squalidness of extreme age, especially when not in elevated circumstances; on the contrary, he is agreeable and attractive, and were he dressed in a superior manner, and placed in a handsome, well furnished apartment, he would be a most beautiful old man."*

The general causes of death have already been mentioned. But in women, the operation of these causes is frequently retarded. In the female sex, the bones, the cartilages, the muscles, as well as every other part of the body, are softer and less solid than those of men; neither are they generally so much subjected to bodily exertions. Their constituent parts, accordingly, require more time in hardening to that degree which occasions death. Women, of course, ought to live longer than men. This reasoning is confirmed by the bills of mortality; for, upon consulting them, it appears, that, after women have passed a certain time, they live much longer than men who have reached the same period. The duration of the lives of animals may, in some measure, be estimated by the time occupied in their growth. An animal, or even a plant, as we learn from experience, which acquires maturity in a short time, perishes much sooner than those which are longer in arriving at that period. In the human species, when individuals grow with uncommon rapidity, they generally die young. This circumstance seems to have given rise to the common proverbial expression, "soon ripe, soon rotten." Man

* Silliman's Tour between Hartford and Quebec in the summer of 1819, p. 172. 'This old man has, I believe, since died. In the 10th Vol. 2d Series of the Massachusetts Historical Collections, there is an account of a number of instances of longevity which have been known to occur in New Hampshire. Within the ten years from 1810 to 1820, eighty persons are recorded who died above the age of 90, twenty-nine of whom reached or exceeded the age of 100. Besides these there have died in the state within the last century—one person of 120—one of 116—one of 115—one of 110—one of 108—one of 107—one of 106—several of 105, and there were living, in 1822, at Chesterfield, a woman of 105, and, at Row, a man of 112. The population of New Hampshire in 1810 was 214,460, and in 1820, 243,236.'

grows in stature till he is sixteen or eighteen years of age; but the thickness of his body is not completely unfolded before that of thirty. Dogs acquire their full length in one year; but their growth in thickness is not finished till the end of the second. A man, who continues to grow for thirty years, may live ninety or a hundred; but a dog, whose growth terminates in two or three years, lives only ten or twelve years. The same observation is applicable to most animals. Fishes continue to grow for a great number of years. Some of them, accordingly, live during several centuries; because their bones aud cartilages seldom acquire the density of those of other animals. It may, therefore, be considered as a general fact, that large animals live longer than small ones, because the former require more time to complete their growth. Thus the causes of our dissolution are inevitable; and it is equally impossible to retard that fatal period, as to change the established laws of nature. When the constitution is sound, life may, perhaps, by moderating the passions, and by temperance, be prolonged for a few years. But the varieties of climate, and of the modes of living, make no material differences with regard to the period of our existence, which is nearly the same in the European, the Negro, the Asiatic, the American, the civilized man and the savage, the rich and the poor, the citizen and the peasant. Neither does the difference of food, or of accommodation, make any change in the duration of life. Men who are fed on raw flesh or dried fish, on sago or rice, on cassada or roots, live as long as those who use bread and prepared victuals. If luxury and intemperance be excepted, nothing can alter those laws of mechanism which invariably determine the number of our years. Any little differences which may be remarked in the term of human life, seem to be chiefly owing to the quality of the air. In general, there are more old men in high than in low countries. The mountains of Scotland, of Wales, and of Switzerland, have furnished more examples of longevity than the plains of Holland, Flanders, Germany, or Poland. But, if we take a survey of mankind, whatever be the climate they inhabit, or their mode of living, there is no very essential difference in the duration of life. When men are not cut off by accidental diseases, individuals may every where be found who live ninety or a hundred years. Our ancestors, with few exceptions, never exceeded this period; and, since the days of David, king of the Jews, it has undergone no variation. Beside accidental diseases, which are more frequent, as well as more dangerous, in the latter periods of life, old men are subjected to natural infirmities that originate solely from a decay of the different parts of the body. The muscles lose their tone, the head shakes, the hands tremble, the limbs totter, the sensibility of the nerves is blunted, the cavities of the vessels contract, the secretory organs are obstructed, the blood, the lymph, and the other fluids, extravasate, and produce all those symptoms and diseases which are commonly ascribed to a vitiation of the humours. The natural decay of the solids, however, appears to be the original cause of all these maladies. It is true, that a bad state of the fluids proceeds from a depravity in the organization of the solids. But the effects resulting from a noxious change in the fluids produce the most alarming symptoms. When the fluids stagnate, or if, by a relaxation of the vessels, an extravasation takes place, they soon corrupt, and corrode the weaker part of the solids. Hence the causes of dissolution gradually, but perpetually, multiply; our internal enemies grow more and more powerful, and at last put a period to our existence.

With regard to Quadrupeds, the causes of their dissolution are precisely the same with those which destroy the human species, with the exception of those which depend upon the vices and intemperance of mankind. The times of their growth bear, likewise, some proportion to the duration of their lives. The following table will afford a view of the period of arriving at maturity, the length of life of some of the principal quadrupeds, and the number of young which they produce at a birth.

Names.	Period of Maturity.	Length of Life.	No. of young at a birth.
Elephant	30 years	200 years.	1
Rhinoceros	15 or 20	70 to 80	1
Hippopotamus	probably about the same		1
Camel	4	40 to 50	1
Horse	2 or 3	25 to 30	1, rarely 2
Zebra	2	do.	do.
Ass	2	do.	do.
Buffalo	3	15 to 18	1
Ox	2	20	1, rarely 2
Stag	1 or $1\frac{1}{2}$	30 to 35	do.
Rein-deer	2	16	1
Large Apes	3	1	1, sometimes 2

Saiga	1	15 to 20	1, sometimes 2
Roebuck	1 or 1½	12 to 15	1 to 3
Chamois	1	20	do.
Goat	1	8 to 10	1 to 4
Sheep	1	do.	1 to 3
Bear	2	20 to 25	never above 5
Lion	2	do.	3 or 4
Leopard & Tiger	2	about the same	4 or 5
Wolf	2	15 to 20	5 to 9
Dog	1	do.	3 to 6
Fox	1	10 to 12	do.
Cat	less than 1	do.	do.
Dormouse	do.	6	3 to 5
Hog	1	15	6 to 20
Hare	less than 1	7 to 8	2 to 4
Rabbit	do.	do.	4 to 8
Guineapig	6 weeks	7	4 to 12.

Some Birds afford instances of great longevity. In this class of animals, the duration of life is by no means proportioned to the times of their growth. Most of them acquire their full dimensions in a few months, and are capable of multiplying the species the first spring or summer after they are hatched. In proportion to the size of their bodies, birds are much more vivacious, and live longer than either men or quadrupeds. Swans have been said to live three hundred years; but, though mentioned by respectable writers, the assertion is not supported by any authentic evidence. Mr Willoughby, in his Ornithology, remarks, " We have been assured by a friend of ours, a person of very good credit, that his father kept a goose known to be fourscore years of age, and as yet sound and lusty, and like enough to have lived many years longer, had he not been forced to kill her for her mischievousness, worrying and destroying the young geese and goslings." In another part of his valuable work, Mr Willoughby tells us, " that he has been assured by credible persons, that a goose will live a hundred years and more." In man and quadrupeds, the duration of life bears some proportion to the times of their growth. But, in birds, their growth, and their powers of reproduction, are more rapid, though they live proportionally longer. Some species of birds, as all the gallinaceous tribes, can make use of their limbs the moment they issue from the shell; and, in a month or five weeks after, they can likewise employ their wings. A dunghill cock does not acquire his full growth in less than a year. The smaller birds are perfect in four or five months. They grow more rapidly, and produce much sooner than quadrupeds, and yet they live proportionally much longer. In man and quadrupeds, the duration of life is about six or seven times more than that of their growth. According to this rule a cock or a parrot, which arrive at their full growth and powers in one year, should not live above six or seven. But nature knows none of our rules. She accommodates her conduct, not to our shallow, and often presumptuous, conclusions, but to the preservation of species, and to the support and general balance of the great system of animated beings. Ravens, though capable of providing for themselves in less than a year, sometimes have their lives protracted more than a century. The Count de Buffon informs us, that, in several places in France, ravens have been known to arrive at this extraordinary age, and that, at all times, and in all countries, they have been esteemed birds of great longevity.

"Eagles," says Mr Pennant, "are remarkable for their longevity, and for their power of sustaining a long abstinence from food. A golden eagle, which has now been nine years in possession of Owen Holland, Esq. of Conway, lived thirty-two years with the gentleman who made him a present of it; but what its age was when the latter received it from Ireland is unknown. The same bird also furnishes a proof of the truth of the other remark, having once, through the neglect of servants, endured hunger for twenty one days, without any sustenance whatsoever." The pelican that was kept at Mechlin in Brabant during the reign of the Emperor Maximilian, was believed to be eighty years of age. "What is reported of the age of eagles and ravens," says Mr Willoughby, "although it exceeds all belief, yet doth it evince that those birds are very longlived. Pigeons have been known to live from twenty to twenty two years. Even the smaller birds live very long in proportion to the time of their growth and the size of their bodies. Linnets, goldfinches, &c. often live in cages, fifteen, twenty, and even twenty-three years.

Fishes, whose bones are more cartilaginous than those of men and quadrupeds, are long of acquiring their utmost growth, and many of them live to great ages. Gesner gives an instance of a carp in Germany which he knew to be one hundred years old. Buffon informs us, that, in the Count Maurepas' ponds, he had seen carps of one hundred and fifty years of age, and that the fact was attested in the most satisfactory manner. He even mentions one which he supposed to be two hundred years old. Two methods have been devised for ascertaining the age of fishes, namely, by the circles of the scales, and by a transverse section of the back bone. When a scale of a fish is examined by the microscope, it is found to consist of a number of circles one within another, resembling, in some measure, those rings that appear on the transverse sections of trees, by which their ages are computed. In the same manner, the ages of fishes may be ascertained by the number of circles on their scales, reckoning for each ring one year of the animal's existence. The ages of Buffon's carps were chiefly determined by the circles on their scales. The age of fishes that want scales, as the skate and ray kind, may be pretty exactly known by separating the joints of the backbone, and observing minutely the number of rings which the surface exhibits. Both of these methods may be liable to deception; but they are the only natural ones which have hitherto been discovered. The longevity of fishes has been ascribed to several causes. The element in which they live is more uniform, and less subject to accidental changes than the air of our atmosphere. Their bones, which are more of a cartilaginous nature than those of land animals, admit of indefinite extension; of course, their bodies, instead of suffering the rigidity of age at an early period, which is the natural cause of death, continue to grow much longer than those of most land animals.

As to the age of Reptiles, probably from the uninteresting nature of the animals, we have very little information. But two letters of J. Arscott, Esq. of Tehott in Devonshire, concerning the longevity of a *toad*, deserve some notice. These letters were addressed to Dr Milles, Dean of Exeter, and by him communicated to Mr Pennant in the year 1768. "It would give me the greatest pleasure," says Mr Arscott, "to be able to inform you of any particulars worthy Mr Pennant's notice, concerning the toad who lived so many years with us, and was so great a favourite.—It had frequented some steps before the hall door some years before my acquaintance commenced with it, and had been admired by my father for its size (which was of the largest I ever met with), who constantly paid it a visit every evening. I knew it myself above *thirty* years, and, by constantly feeding it, brought it to be so tame, that it always came to the candle, and looked up, as if expect-ing to be taken up and brought upon the table, where I always fed it with insects of all sorts.—You may imagine that a toad, generally detested (although one of the most inoffensive of all animals), so much taken notice of and befriended, excited the curiosity of all comers to the house, who all desired to see it fed; so that even ladies so far conquered the horrors instilled into them by nurses, as to desire to see it." In the second letter, Mr Arscott remarks, "I cannot say how long my father had been acquainted with the toad before I knew it; but, when I was first acquainted with it, he used to mention it as the old toad I have known so many years; I can answer for *thirty six* years."—"In respect to its end, had it not been for a tame raven, I make no doubt it would have been now living, who, one day, seeing it at the mouth of its hole, pulled it out, and, though I rescued it, pulled out one eye, and hurt it so, that, notwithstanding its living a twelvemonth, it never enjoyed itself, and had a difficulty in taking its food, missing the mark for want of its eye. Before that accident it had all the appearance of perfect health."

Most Insects, especially after their last transformation, are shortlived. But the species are continually supported by their wonderful fecundity. Those animals whose parts require a long time of hardening and expanding, are endowed with a proportional degree of longevity. Insects grow, and their bodies harden, more quickly than those of larger animals. Many of them complete their growth in a few weeks, and even in a few days. The duration of their existence is accordingly limited to very short periods. Some species of flies lie in a torpid state during the winter, and revive when the heat of spring or summer returns. The ephemeron flies, of which there are several kinds, seldom live above one day, or one hour, after their transformation. But, to continue the species, nature has taken care that myriads of males and females should be transformed nearly at the same instant. Other kinds are transformed more irregularly, and live several days. Here the wisdom of nature is conspicuous; she prolongs the existence of these animals for no other purpose but to make provision for the continuance of the species. Bees, and flies of all kinds, after lying long in water, and having every appearance of death, revive by the application of a gentle heat, or by covering their bodies with ashes, chalk, or sand, which absorb the superfluous moisture from their pores. Reaumur made many experiments upon the reviviscence of drowned bees. He found, that, after being immersed in water for nine hours, some of them returned to life; but he acknowledges that many of them, in the fourth part of this time, were actually dead, and that neither heat, nor the application of absorbent powders, could restore them to life. Analogical reasoning is often deceitful, but it frequently leads to useful truths. As flies of all kinds, after immersion in water, and exhibiting every mark of actual death, can be restored to life by covering their bodies with any absorbent substance, without the assistance of a heat superior to that of the common atmosphere, might not the ordinary methods employed for the recovery of drowned persons be assisted by the application of warm ashes or chalk? The structure of a fly and that of a man, it is allowed, are very different. But, in desperate cases, when every other method fails, no fact should be overlooked, and no analogy despised.

Plants differ as much in the periods of their existence as animals. Many plants perish yearly; others are biennial, triennial, &c. But the longevity and magnitude of particular trees are prodigious. We are informed by Mr Evelyn, that in the bodies of some English oaks, when cut transversely, three and even four hundred rings of wood have been distinguished. A ring of wood is added annually to the trunks of trees; and, by counting the rings, the age of any tree may be pretty exactly ascertained. With regard to the magnitude of oaks, some of them are huge masses. Dr Hunter, in his notes upon Evelyn's Sylva, remarks, that none "of the oaks mentioned by Mr Evelyn bear any proportion to one now growing at Cowthrope, near Wetherby, upon an estate belonging to the Right Hon. Lady Stourton. The dimensions are almost incredible. Within three feet of the surface, it measures sixteen yards, and, close by the ground, twenty-six yards. Its height, in its present and ruinous state (1776), is about eighty-five feet, and its principal limb extends sixteen yards from the bole. When compared to this, all other trees are but children of the forest."

From the facts which have been enumerated, it appears, that all animals, as well as vegetables, have stated periods of existence, and that their dissolution is uniformly accomplished by a gradual hardening and desiccation of their constituent parts. No art, no medicine, can retard the operations of nature. It is, therefore, the wisdom and the duty of every human being to sail down the irresistible current of nature with all possible tranquillity and resignation. Life, whether short or long, whether fortunate or unfortunate, when the fatal period arrives, is of little consequence to the individual. Society, knowledge, virtue, and benevolence, are our only rational enjoyments, and ought to be cultivated with diligence.

With regard to animals in general, the actual duration of their lives is very different. But the comparative shortness or length of life, in particular animals, probably depends on the quickness or slowness of the ideas which pass in their minds, or of the impressions made upon their senses. A rapid succession of ideas or impressions makes time seem proportionally long. There is likewise a connexion between the quickness and slowness of ideas, and the circulation of the blood. A man whose pulse is slow and sluggish, is generally dull and phlegmatic. Raise the same man's pulse with wine, or any other exhilarating stimulus, and you immediately quicken his sensations, as well as the train of his ideas. In all young animals, the circulation of the blood is much more rapid than after they have acquired their full growth. Young animals, accordingly, are frolicksome, vivacious, and happy. But, when their growth is completed, the motion of the blood is slower, and their manners, of course, are more sedate, gloomy, and pensive. Another circumstance merits attention. The circulation of the blood is slower or quicker in proportion to the magnitude of animals. In large animals, such as man and quadrupeds, the blood moves slowly, and the succession of their ideas is proportionally slow. In the more minute kinds, as mice, small birds, squirrels, &c. the circulation is so rapid that the pulsations of their arteries cannot be counted. Now, animals of this description astonish us with the quickness of their movements, the vivacity of their manners, and the extreme cheerfulness of their dispositions.

Reaumur, Condillac, and many other philosophers, consider duration as a relative idea, depending on a train of conscious perception and sentiment. It is certain that the natural measure of time depends solely on the succession of our ideas. Were it possible for the mind to be totally occupied with a single idea for a day, a week, or a month, these portions of time would appear to be nothing more than so many instants. Hence a philosopher often lives as long in one day, as a clown or a savage does in a week or a month spent in mental inactivity and want of thought.

This subject shall be concluded with a single remark ; if it be true, and we are certain that it is so in part, that animals of every species, whatever be the real duration of their lives, from a slow or rapid succession of ideas, and perhaps from the comparative intensity of their enjoyments, live equally long, and enjoy an equal portion of individual happiness, it opens a wonderful view of the great benevolence of Nature. To store every portion of this globe with animal life, she has amply peopled the earth, the air, and the waters. The multifarious inhabitants of these elements, as to the actual duration of their lives, are extremely diversified. But, by variation of forms, of magnitude, of rapidity of ideas, of intensity of pleasures, and, perhaps, of many other circumstances, she has conferred upon the whole nearly an equal portion of happiness.

CHAPTER XIV.

OF THE PROGRESSIVE SCALE OR CHAIN OF BEINGS IN THE UNIVERSE.

To men of observation and reflection, it is apparent, that all the beings on this earth, whether animals or vegetables, have a mutual connexion and a mutual dependence on each other. There is a graduated scale or chain of existence, not a link of which, however seemingly insignificant, could be broken without affecting the whole. Superficial men, or, which is the same thing, men who avoid the trouble of serious thinking, wonder at the design of producing certain insects and reptiles. But they do not consider that the annihilation of any one of these species, though some of them are inconvenient, and even noxious to man, would make a blank in nature, and prove destructive to other species, which feed upon them. These, in their turn, would be the cause of destroying other species, and the system of devastation would gradually proceed, till man himself would be extirpated, and leave this earth destitute of all animation.

In the chain of animals, man is unquestionably the chief or capital link. As a highly rational animal, improved with science and arts, he is, in some measure, related to beings of a superior order, wherever they exist. By contemplating the works of Nature, he even rises to some faint ideas of her great Author. Why, it has been asked, are not men endowed with the capacity and powers of angels? beings of whom we have not even a conception. With the same propriety, it may be asked, Why have not beasts the mental powers of men? Questions of this kind are the results of ignorance, which is always petulant and presumptuous. Every creature is perfect, according to its destination. Raise or depress any order of beings, the whole system, of course, will be deranged, and a new world would be necessary to contain and support them. Particular orders of beings should not be considered separately, but by the rank they hold in the general system. From man to the minutest animalcule which can be discovered by the microscope, the chasm seems to be infinite; but that chasm is actually filled up with sentient beings, of which the lines of discrimination are almost imperceptible. All of them possess degrees of perfection or of excellence proportioned to their station in the universe. Even among mankind, which is a particular species, the scale of intellect is very extensive. What a difference between an enlightened philosopher and a brutal Hottentot? Still, however, Nature observes, for the wisest purposes, her uniform plan of gradation. In the human species, the degrees of intelligence are extremely varied. Were all men philosophers, the business of life could not be executed, and neither society, nor even the species could long exist. Industry, various degrees of knowledge, different dispositions, and different talents, are great bonds of society. The Gentoos, from certain political and religious institutions, have formed their people into different casts or ranks, out of which their posterity can never emerge. To us, such institutions appear to be tyrannical, and restraints on the natural liberty of man. In some respects they are so; but they seem to have been originally results of wisdom and observation; for, independently of all political institutions, nature herself has formed the human species into casts or ranks. To some she gives superior genius and mental abilities; and, even of these, the views, the pursuits, and the tastes, are most wonderfully diversified.

In the talents and qualities of quadrupeds of the same species, there are often remarkable differences. These differences are conspicuous in the various races of horses, dogs, &c. Even among the same races, some are bold, sprightly, and sagacious. Others are comparatively timid, phlegmatic, and dull.

Our knowledge of the chain of intellectual and corporeal beings is very imperfect; but what we do know gives us exalted ideas of that variety and progression which reign in the universe. A thick cloud prevents us from recognising the most beautiful and magnificent parts of this immense chain of being. We shall endeavour, however, to point out a few of the more obvious links of that chain, which falls under our own limited observation.

Man, even by his external qualities, stands at the head of this world. His relations are more extensive, and his form more advantageous, than those of any other animal. His intellectual powers, when improved by society and science, raise him so high, that, if no degrees of excellence existed among his own species, he would leave a great void in the chain of being. Were we to consider the characters, the manners, and the genius of different nations, of different provinces and towns, and even of the members of the same family, we should imagine that the species of men were as various as the number of individuals. How many gradations may be traced between a stupid Huron, or a Hottentot, and a profound philosopher? Here the distance is immense; but nature has occupied the whole by almost infinite shades of discrimination.

'In descending the scale of animation, the next step brings us to the monkey tribe. Man, in many particulars, undoubtedly resembles the animals of this tribe, more especially in his bodily structure. But even in this respect, the lowest variety of the human species does not nearly so much resemble the highest of the apes, as the latter do the majority of quadrupeds. In short, notwithstanding the attempts of some philosophers to confound their own species with monkeys, it requires only a small share of knowledge of the anatomical structure of animals, and the general principles of natural history, to convince any one of the folly and absurdity of such speculations.

'In the families of bats, of carnivorous, and of gnawing animals, there is a gradual departure in their form and structure from that of the original standard, man. Instead of fingers fitted for delicate motions and sensations, they are possessed only of claws which are capable of far less varied application and utility; and passing on still farther we find in the ruminating and pachydermatous animals the toes enveloped in hoofs of different sizes and numbers, which totally prevent them from being used for any thing but locomotion.

'There is not only this regular gradation among individuals belonging to the same class, but there are instances in which the individuals of different classes very nearly approach each other in certain particulars. The bat, the flying squirrel, the flying opossum, are instances of animals of the class mammalia, approximating to that of birds in the possession of wings or organs resembling them, whilst the ornithorhynchus resembles them in the structure of its mouth, and its mode of producing its young by eggs. On the other hand the ostrich, the cassowary and the dodo, which have wings so short as to be incapable of flying, and therefore always run or walk, are instances of birds approaching, in some degree, to the character of quadrupeds. So too, the cetaceous tribe affords an example of the transition from the mammalia to fishes; the flying fish, of the transition from birds to fishes; the dragons, of that from birds to reptiles. Many other examples might be adduced in illustration of the same principle, among the vertebral animals; and among the invertebral, the connexions and relations of this sort are so numerous, as to form a great obstacle to the proper division of them into classes and orders.'

All the substances we recognise on this earth may be divided into organized and animated, organized and inanimate, and unorganized or brute matter. The whole of these possess degrees of perfection, of excellence, or of relative utility, proportioned to their stations or ranks in the universe. Change these stations or ranks, and another world would be necessary to contain and support them. Beings must not be contemplated individually, but by their rank, and the relations they have to the constituent parts of the general system of nature. Certain results of their natures we consider as evils. Destroy these evils, and you annihilate the beings who complain of them. The reciprocal action of the solids and fluids constitutes life, and the continuation of this action is the natural cause of death. Immortality on this earth, therefore, presupposes another system; for our planet has no relation to immortal beings. Every animal, and every plant, rises, by gentle gradations, from an embryo, or gelatinous state, to a certain degree of perfection exactly proportioned to their several orders. An assemblage of all the orders of relative perfection constitutes the absolute perfection of the whole. All the planets of this system gravitate toward the sun and toward each other. Our system gravitates toward other systems, and they to ours. Thus the whole universe is linked together by a gradual and almost imperceptible chain of existences both animated and inanimate. Were there no other argument in favour of the UNITY OF DEITY, this uniformity of design, this graduated concatenation of beings, which appears not only from this chapter, but from many other parts of the book, seems to be perfectly irrefragable.

'In contemplating man as at the head of those animals with which we are acquainted, and viewing him in connexion with the economy of the world about him, it appears obvious that no sentient being, whose physical construction was more delicate, or whose mental powers were more elevated, than those of man, could possibly live and be happy here. If such a being really existed, his misery would be extreme. With senses more refined and acute; with perceptions more delicate and penetrating; with a taste, so exquisite that the objects around him could by no means gratify it; obliged to feed upon nourishment too gross for his frame; he must be born only to be miserable, and the continuation of his existence would be utterly impossible. Even in our present condition, the sameness and insipidity of objects and pursuits, the futility of pleasure, and the infinite sources of excruciating pain, bring constantly to our minds a conviction of the imperfections attendant on our present state of being. Increase our sensibilities, continue the same objects and situation, and no man could bear to live. Let man therefore be contented with the powers and the sphere of action assigned him. There is an exact adaptation of his powers, capacities, and desires, both bodily and intellectual, to the scene in which he is destined to move. His station in the scale of nature is fixed by wisdom. Let him study the works of nature, and find in the contemplation of all that is beautiful, curious, and wonderful in them, proofs of the existence and attributes of his Creator. Let him see in his own structure and that of all other animals, and in the whole economy of the universe, animate and inanimate, the evidences of the wisdom, the skill, the benevolence, and the justice, of that great and overruling Intelligence, who has made all things and who upholds all things. Let him find in the contemplation of the final destiny which is promised him, a source of consolation for the imperfections, pains, and trials, of the present state of being. Let him fill up his rank here with dignity, and consider every partial evil as a cause, or an effect, of general ultimate good; and let him adore and worship that great and good Being, who has, even in this state of discipline and probation, dispensed so many blessings to alleviate its necessary and unavoidable evils.'

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EXPLANATION

OF SOME OF THE SCIENTIFIC TERMS OR UNUSUAL WORDS WHICH OCCUR IN THE COURSE OF THIS WORK.

Accipitrine, belonging to the first order of birds, called *Accipitres*, Birds of Prey.*

Alburnum, the outer and most recent layer of wood in trees.

Alluvia, soils formed from the muddy sediment of rivers, or from the earth washed down by rains and torrents from mountains.

Ammonia, or *Ammoniacal Gas*, a pungent air which gives its peculiar qualities to volatile salts or Hartshorn drops.

Antennæ, organs of touch situated near the mouth of insects, having many joints.

Anther, a small body which contains the pollen or fertilizing dust of flowers; the antheræ are fixed generally on the ends of slender filaments and surround the germ or seed-vessel.

Articulations, joints formed by the union of bones.

Auricles, two appendages to the heart, so called from their supposed resemblance to the external ear (auricula). They are hollow and muscular. Their office is described, p. 24, 25.

Azote, See *Nitrogen*.

Bimanous, two handed; belonging to the order Bimana.

Bivalved, having two valves or shells; applied to shell-fish, as the oyster, clam, &c.

Calcareous, composed of lime.

Caloric, the ultimate principle of heat.

Canine, as applied to the teeth, designates those commonly called dog-teeth or eye-teeth. They are peculiarly adapted to tearing flesh, p. 27.

Capillary, hair-like. The extreme vessels of the body are so called on account of their indefinite minuteness.

Carbon, pure charcoal; it is a component part of most animal and vegetable substances.

Carbonic acid gas, fixed air; the gas produced by the burning of charcoal, and the effervescence of chalk, marble, and other calcareous substances, with acids.

Carbonic oxide, a gas, composed of carbon and oxygen.

Carburetted hydrogen, hydrogen combined with a portion of carbon.

Cartilage, gristle.

Cellular, composed of cells.

Cetaceous, of the whale kind ; belonging to the order *Cetacea*.

Chlorine, a highly irritating and deleterious gas, produced by the distillation of manganese with muriatic acid.

Chrysalid, an insect in its second or chrysalis state. p. 71.

Cod, the case or envelope formed by many insects to enshroud and protect them during the chrysalis state.

Comminution, grinding, or breaking up into small parts.

Condiments, substances taken with the food, not containing any nourishment, but used as seasoning, to promote appetite and digestion, as salt, pepper, &c.

Congeries, a collection, a heap.

Crustaceous, belonging to the class *Crustacea*, having a shelly covering with joints, allowing the free motion of the body and limbs.

Crystalline Lens, a doubly convex lens, formed of a transparent animal substance, situated within the eye, and serving to collect the rays of light passing in at the pupil, and to transmit them to the retina.

Diaphragm, the midriff; a broad, thin, muscular membrane, extending across the cavities of the trunk of the body, and separating the thorax or chest, from the abdomen or belly.

Dormant, as applied to animals, designates those which pass a part of the year in a state of torpidity.

Elytra, cases, the horny or shell-like external wings of some insects.

Espalier, trees planted and cut so as to join.

Extravasate, to pass or force out of the proper containing vessels. Blood which settles under the skin in consequence of a blow, is said to be extravasated.

Farina, the dust which bees collect from the antheræ and flowers of plants to form into wax.

Filament, a substance long and slender like a thread.

Frugivorous, feeding upon fruits.

Fulcrum, the point of support on which a lever is moved.

Gallinaceous, belonging to the fourth order of birds, *Gallinaceæ*.

Gas, a term used in chemistry, nearly synonymous with *air*. All fluids which remain in an aeriform state at the ordinary pressure and temperature of the atmosphere are called gases.

Gastric, appertaining to the stomach.

Gastric juice, a fluid prepared by the stomach to assist in dissolving and digesting the food.

Gelatinous, of the composition or consistence of jelly.

Glands, organs in living bodies intended for the secretion, or separation from the blood, of fluids of various kinds ; as the liver which separates the bile ; the kidneys, the urine, &c.

Graminivorous, feeding upon grass.

Gregarious, living in flocks and herds.

Herbivorous, feeding upon herbs, i. e. plants whose stems are soft and have but little that is woody or fibrous in their texture.

Homogeneous, having the same nature or principle.

Hydrogen, one of the elements of water; it can only be obtained in the state of a very light and inflammable gas.

Imbricated, arranged like slate or tiles on a roof, or like the scales of fish.

Incisors, Incisive teeth, the front or cutting teeth. p. 27.

Incubation, the sitting upon and hatching of eggs.

Intumescence, swelling, enlargement.

Invertebral, without vertebræ, or back-bone; used to designate one of the two grand divisions of the animal kingdom, including those which have no internal skeleton.

Larva, an insect in its first state, commonly called a worm or caterpillar. p. 71.

Lens, any circular transparent body with either convex or concave surfaces, for the purpose of collecting or dispersing the rays of light.

Locomotion, motion from place to place.

Macerate, to soak a substance in any liquid, till its texture is destroyed.

Marsupial. Animals having a pouch or bag (marsupium) for containing their young after birth, are called *Marsupial* animals; in this work they are all arranged under one order, *Marsupialia*, but have been usually distributed among the other orders.

Mastication, the act of chewing the food and mixing it with saliva.

Membranes, thin, broad expansions of animal substance, covering all the important organs and lining all the organs and cavities in the bodies of animals. Thus the nose is lined by the *schneiderian* or *pituitary*, and the eye covered by the *conjunctive* membrane; the stomach and bladder are each formed of several membranes laid together.

Menstruum, a dissolvent, any substance in which another substance may be dissolved.

Molares, Molar teeth, the grinders or double teeth. p. 27.

Mucus, a viscid animal fluid; such as the *phlegm* which is poured out from the nose, or raised up from the throat in common colds.

Multivalved, having many valves or shells; applied to some shell-fish, as the sea-urchin, sea-egg, &c.

Muscles, (in Anatomy) bundles of fibrous flesh, fixed by tendons or sinews to the bones, and serving to move them one upon another at their joints. In the mammalia, birds, and some reptiles, they are of a red colour; in other animals for the most part white. They constitute the greatest portion of the flesh of animals, and are the parts principally used as food.

Nectariferous, bearing or producing honey; applied to certain parts of plants from which honey is collected.

Nidus, a nest; any place where the eggs of animals are deposited for hatching.

Nitrogen or *Azote*, one of the gases which compose atmospheric air; its qualities are negative and its principal use seems to be merely to dilute the oxygen.

Nitrous oxide, a gas composed of oxygen and nitrogen in different proportions from those in which they exist in atmospheric air; remarkable for its power of intoxicating and exhilarating those who breathe it.

Nymphæ, *nymphs*, insects in their second or chrysalis state.

Œsophagus, the gullet; the passage through which the food passes from the mouth to the stomach.

Oviparous, producing young by means of eggs.

Oxygen, vital air; the principle upon which atmospheric air depends for its power of supporting life and combustion. It forms also one of the component parts of water.

Pachydermatous, thick-skinned; belonging to the order *Pachydermata*.

Palpi, organs situated near the mouth of some insects, resembling in some degree the antennæ in their structure.

Papier maché, chewed paper.

Papillæ. The terminations of the nerves in the skin and other organs of sense, are supposed to form little eminences, which are called *papillæ*.

Papion à perruque, baboon with a wig.

Parachute, a machine often attached to an air balloon, and constructed so as to open like an umbrella, and break the fall of a person descending from any great height in the air.

Passerine, belonging to the order *Passeres*, or birds of the sparrow kind.

Peristaltic, the intestines of animals are constantly undergoing a sort of motion, by which their contents are moved through them, which appears like that of the creeping of a worm. It is called their vermicular or *peristaltic* motion.

Permanently elastic, applied to fluids, denotes those which retain their elastic state at the ordinary pressure and temperature of the atmosphere.

Petals, the coloured leaves of the flowers of plants.

Pituitary, one of the names of the membrane lining the nose.

Quadrumanous, four-handed, belonging to the order *Quadrumana*.

Radiation of heat, the passing of heat from bodies through an intervening space in rays like light, used in contradistinction to the direct transmission of heat by contact.

Radiated, arrayed like the radii or rays of a circle.

Rationale, a detail of any course of phenomena or operations with the principle or reason on which they proceed.

Retina, a nervous membrane situated at the back part of the eye, and intended to receive the images of external objects; formed by the expansion of the optic nerve as it comes out from the brain into the eye.

Retrograde, going backward, moving backward.

Reviviscence, renewal of life.

Rugosity, roughness, inequality of any kind.

Ruminate, to chew the cud; this operation is described, p. 46.

Saliva, spittle, the liquid which moistens the mouth, and mixes with the food in mastication.

Sapid, having taste.

Schneiderian, one of the names of the membrane lining the nose, derived from the name of the anatomist who first described it.

Sea-anemone, an animal of the class Zoophytes, so called from some degree of resemblance in its form to an expanded flower.

Serrated, notched like a saw.

Spinal, belonging to the back-bone or spine.

Spleen, a small oblong organ situated on the left side of the stomach, just under the ribs; of a reddish blue, or purple colour and very full of blood.

Stalactites, substances deposited in caves or the fissures of rocks, from the droppings of water which contains lime in solution.

Sternum, the breast-bone.

Stigma, in Botany, the extremity of the germ or seed-vessel of flowers.

Stimuli, substances which stimulate or excite.

Strata, beds, layers.

Subclavian, lying underneath the clavicle or collar-bone; as the subclavian artery, the subclavian vein.

Substratum, foundation, groundwork.

Subtend. A line which passes across from one of the lines forming an angle, to the other, is said to subtend that angle.

Sulphuretted Hydrogen, hydrogen combined with a portion of sulphur.

Suture, a mode of union which takes place in the bones of the head and face, in which the edge of one bone is let into that of another by means of corresponding indentations in each, the line of union appearing like a seam (sutura), whence the name.

Tendons, white, smooth, and strong cords by which muscles are generally fixed to the bones; usually called cords or sinews.

Tendrils, the filaments by which creeping or climbing plants attach themselves to other objects for support, as those of the vine, ivy, &c.

Tentacula, often called feelers; organs supplying the place of hands and arms to some animals, intended both for feeling, and for seizing and holding food or other substances, or conveying them to the mouth.

Testaceous, having a shelly covering, but without joints or articulated limbs.

Thorax, the chest, a cavity in the body formed by the back-bone behind, the sternum before, the ribs on each side, and the diaphragm below, which last separates it from the abdomen.

Triturate, to pound up or reduce to powder, as in a mortar.

Truncated cone, a cone divided, or cut off.

Univalved, having only one shell or valve, applied to shell-fish, as the cockle, nautilus, &c.

Vascular, consisting of vessels, relating to vessels, i. e. arteries, veins, &c.

Venous, appertaining to the veins.

Ventricles, muscular cavities of the heart, which receive the blood from the auricles and transmit it by their contraction through the arteries. Their office is described, p. 24, 25.

Vertebræ, the bones of which the back-bone is composed.

Vertebral, having vertebræ; used to designate one of the grand divisions of the animal kingdom, and including those animals which have an internal skeleton.

Viscus, plural *Viscera*; used principally to designate organs contained in the great cavities of the body, as the brain, heart, stomach, &c.

Viviparous, producing young alive.