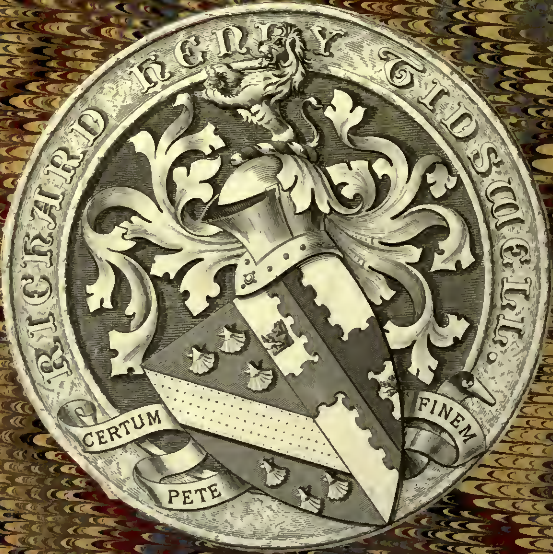
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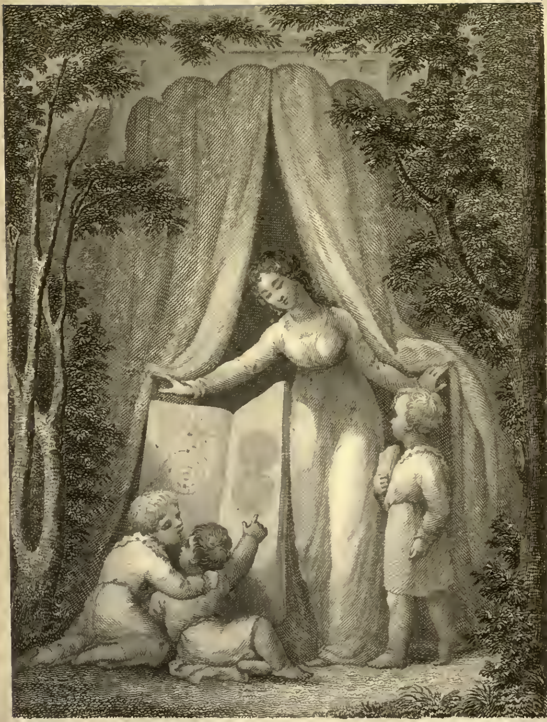

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SCIENCE UNVEILING THE BOOK OF KNOWLEDGE.

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A COMPENDIUM

OF

NATURAL PHILOSOPHY,

BEING

A SURVEY OF THE WISDOM OF GOD IN THE CREATION;

BY JOHN WESLEY, A.M.

A NEW EDITION,

REVISED, CORRECTED, AND ADAPTED TO THE PRESENT STATE OF SCIENCE,

BY ROBERT MUDIE;

AUTHOR OF "A GUIDE TO THE OBSERVATION OF NATURE," ETC.

In Three Volumes.

VOL. I.

MAN—VERTEBRATED ANIMALS.

LONDON:
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PREFACE

BY THE AUTHOR.

I.—I have long desired to see such a Compendium of Natural Philosophy as was, first, not too diffuse, nor expressed in many words, but comprised in so moderate a compass as not to require any large expense either of time or money; secondly, not maimed or imperfect, but containing the heads of whatever, after all our discoveries, is known with any degree of certainty, either with regard to the earth or the heavens. And this I wanted to see thirdly, in the plainest dress; simply and nakedly, expressed in the most clear, easy, and intelligible manner that the nature of the things would allow, particularly free from all the jargon of mathematics, which is mere heathen Greek to common readers. At the same time I wished to see this short, full, plain account of the visible creation, directed to its right end; not barely to entertain an idle barren curiosity, but to display the invisible things of God; his power, wisdom and goodness.

II.—But I cannot find such a treatise as this in any modern, any more than ancient language; and I am certain there is none such in the English tongue. What comes nearest to it of anything I have seen, is Mr. Ray's "Wisdom of God in the Creation;" Dr.

Derham's "Physico and Astro-Theology;" Nieuwentyt's "Religious Philosopher;" Mather's "Christian Philosopher and Nature delineated." But none of these, singly, answers the design; and who will be at the pains to extract the substance of them all and add the later discoveries, of which they had little knowledge, and therefore could take but little notice? This is a desideratum still, and one that a lover of mankind would rejoice to see even tolerably supplied.

III.—I am thoroughly sensible there are many who have far more ability, as well as leisure for such a work than me; but as none of them undertake it, I have myself made some little attempt in the ensuing volumes. Herein following Mr. Derham's plan, I divide the work into text and notes.* The text is, in great measure, translated from the Latin work of John Francis Buddæus, the late celebrated professor of philosophy in the University of Jena, in Germany. But I have found occasion to retrench, enlarge, or alter every chapter, and almost every section, so that it is now, I believe, not only pure, containing nothing false or uncertain, but as full as any tract can be expected to be which is comprised in so narrow a compass; and likewise plain, clear, and intelligible, to one of a tolerable understanding. The notes contain the sum of what is most valuable in the above-named writers; to which are added the choicest discoveries both of our own and of the foreign societies. These likewise, I trust, are as plain and clear as the nature of the things spoken of will allow; although some of them, I know, will not be understood by an unlearned or inattentive reader.

* So it was in the first edition. Many of these are now taken into the text.

IV.—Meantime I must apprise the reader that I have sometimes a little digressed, by reciting both uncommon appearances of nature, and uncommon instances of art: and yet this is not properly a digression from the main design I have in view. For surely in these appearances also the wisdom of God is displayed; even that manifold wisdom which is able to answer the same ends by so various means. And those surprising instances of art do likewise reflect glory upon him, whose spirit in man giveth that wisdom, whose inspiration teacheth understanding.

V.—It will be easily observed, that I endeavour throughout not to account for things, but only to describe them. I undertake barely to set down what appears in nature, not the cause of those appearances. The facts lie within the reach of our senses and understanding, the causes are more remote. That things are so we know with certainty, but why they are so we know not. In many cases we cannot know; and the more we inquire the more we are perplexed and entangled. God hath so done his works that we may admire and adore, but we cannot search them out to perfection.

VI.—And does not this open to us another prospect? although one we do not care to dwell upon. Does not the same survey of the creation which shows us the wisdom of God show the astonishing ignorance and short-sightedness of man? For when we have finished our survey, what do we know? How inconceivably little! Is not every thinking man constrained to cry out, And is this all? Do all the boasted discoveries of so enlightened an age amount to no more than this? Vain man would be wise! But with how little success does he attempt it? How small a part do we know even of the things that encompass us on every side? I mean as to the very fact; for as to the reasons, of almost everything which we see, hear, or feel, after all our researches and disquisitions, they are hid in impenetrable darkness.

VII.—I trust, therefore, the following sheets may, in some degree, answer both these important purposes. It may be the means, on the one hand, of humbling the pride of man, by showing that he is surrounded on every side with things which he can no more account for than for immensity or eternity; and it may serve on the other to display the amazing power, wisdom, and goodness of the great Creator; to warm our hearts, and to fill our mouths with wonder, love, and praise!

JOHN WESLEY.

PREFACE

BY THE EDITOR.

The notion which the amiable and justly celebrated John Wesley had of the easiest method of obtaining a popular knowledge of the works of nature and a right feeling of reverence for the Author of nature, as his wisdom, power, and goodness are displayed in those works, can be seen from his own Preface, as given in the preceding pages; and when we consider the state of human knowledge at the time when Wesley obtained his information, more especially as regarded the laws of nature and the mutual relations and dependencies of natural productions and phenomena, we must at once admit that, for its time, the original work was an excellent one.

The time of it has however now gone by. Not less than a hundred years have passed away since Wesley studied; and during those years, the progress of all sciences, and of the natural sciences in an especial manner, has been greater than during the whole previous period of human history. If we leave out of the question the mathematical sciences, which, though not exactly "Heathen Greek to common readers," as Wesley says, have yet no direct and immediate bearing upon the science of terrestial nature, until they are combined with other elements,—if we leave out these sciences, we may say that the only principles which had then assumed a proper form, were those of the mechanical sciences. Chemistry, without which we can hardly advance a step in the proper investigation of nature, could not be said to exist; and on the subject of natural action, —heat, light, electricity, magnetism, and the powers of growth and of life, there were only a few detached hints and insulated facts, which were matters of wonder and not of philosophy.

Such being the case with regard to those elementary sciences, which we must bring to the useful investigation of nature as the very instruments of our working, it could no more be expected that accurate knowledge of nature could exist, than we could look for finished productions of art from people not possessing a tool. Gravitation may be said to have been the only general principle of which the laws were then fully understood; and by far too much was, as we might expect, made of this principle; for, just as men who have but one instrument apply it to all uses, so were the principles of mechanical philosophy applied at that time to all matters. Or, if there was any proof or reasoning, in supplement to that of a mechanical kind, it was grounded chiefly upon *authorities* a foundation upon which no solid or useful structure of a philosophical nature can ever be raised.

The progressive dawn of the light of science upon the nations, may be not inaptly compared to the progress of the dawn of day upon the earth and the heavens. In the earlier glimmerings of day-break, the stars which show their chief glories during the night, are still visible, though they wax fainter and fainter as the sun approaches the horizon. While there are stars only, all the earth is in shadow, so that we have no knowledge of it; and, in proportion as the stars apparently fade away, the face of nature is revealed to us; and when at last the beam of the morning comes in its power, the sky is starless. If the surface of the land is greatly diversified with mountain and valley, it often happens that while the early sun-beams illuminate the mountain-tops, which are cold and barren, all the valleys that lie between, and which are the rich and valuable parts, are concealed by fogs and shadows; nor is it till the full glory of the sun has come upon the whole surface, that all nature, with the exception of those stars which that radiance has veiled, lies open to the contemplation and ready for the use of man. It is even so with the light of science; at its first glimmering, men are still guided by the stars of authority; and when the radiance of truth begins to break on a point here and there, those points seem sublime, like the mountain tops, but, like these, they are cold, barren, and unconnected with each other and with usefulness. In proportion as the light of science advances, the stars of science lose their authority; and men begin to see with their own eyes, and to judge by their own understandings; and if we could look forward (and the hope is enticing) to a period, when this radiance shall beam full upon all the people, and the light of genuine truth show every object to every observer, then the sky of knowledge would be as starless, as is the natural sky under the full glory of the meridian sun.

I do not say that this delightful state of things has yet arrived, but there have certainly been wonderful advances since the time at which Wesley wrote his book; and though we admit, as I am very ready to admit, that Wesley made the best use of such materials as his eyes furnished him, yet those materials are certainly not adapted to the present state of human knowledge.

Being engaged to revise the work, and left to my own judgment in the revision, I have been anxious to do justice both to the character of Wesley and to the public; and finding that no verbal or other slight alterations could at all bring the work into an accordance with the present state of things, I have taken and have acted upon what appeared to me to be the most rational view of the matter. The original preface will show what was intended; and I have endeavoured, to the best of my ability, to put myself in the stead of Wesley, supposing him to be now living, and have endeavoured to produce such a work as he would most likely have produced if writing it at the same time as I was. This is a matter in which there cannot be an absolute coincidence; because it is impossible to get hold of even all the leading points of Mr. Wesley's character, or to know how he would have acted if he had been a member of the present generation. Therefore all the faults and failings of the book must be chargeable against me; and all that I have to plead is, that I have done my best to avoid both.

The work at first appeared in five volumes, but I have reduced it to three, though with an increase of the quantity of matter. In thus reducing the number of volumes I have had two objects in view:—first, to render the price of the whole work as small as possible, and by that means to place it within the reach of a great number of readers; and, in the second place, this division into three volumes has enabled me to make each volume so far complete in itself, as relating to one portion of nature though it will most likely be found that all the volumes are necessary to the complete understanding of any one of them. I have followed Wesley's arrangement, though I have separated many things, and also brought many others together, the relations of which were quite unsettled when he wrote. The first volume relates to man, and to the vertebrated animals, mammalia, birds, reptiles, and fishes. The notices of these latter are necessarily very brief; but I think that even in this brevity there will be found an advantage to the common reader, which is not to be met with in any other work in our language. The portion which relates to man is the only one in which I have retained much of what was originally in the work; and I have been enabled to do this because the anatomical structure of man was better understood than any other part of natural history at the time when Wesley wrote. Even here, however, I have felt it necessary to omit those mechanical explanations of the operation of the senses, and those theories of animal spirits, and other gratuitous matters, which are calculated only to mislead. I have also introduced many physiological points which have been settled since Wesley's time; and I think it will be found that I have added some which are not to be met with in any other work, more especially with regard to the first commencement of living action, and the transition of the fœtus from the uterine to the aerial locality. In the vertebrated animals I have chiefly followed the system of the late Baron Cuvier; but I have added various points upon which light has been thrown since that most able and candid expounder of nature quitted this mortal scene.

The second volume contains a notice of the invertebrated animals, down to the very verge of animal existence; and after that an account of plants, which however, from the narrow limits to which I am necessarily confined, is physiological rather than descriptive.

In the third volume I have noticed the leading principles and phenomena of nature considered as inorganic, or not under the control of, or produced by, the powers of life and of growth. This too, is a most extensive field, so that a mere line through it is all that I could pretend to take; but in taking this I have endeavoured, as much as possible, to seize those commanding points which are in some measure the keys to the whole.

In the whole work I have endeavoured to make it, in some sort, an introduction to all the particular works on detached portions of nature, to those who are beginning the study, or as a summing up to such as have already studied the details; and if I have succeeded even moderately in this, the work will be found equally useful to those who are about to begin the study of nature, and those who, wearied and worn with the particulars, are desirous of refreshing themselves with a general view of the whole. In every part of the work I have studiously avoided technical expressions, and also those debateable points which are interesting only to professional students; but at the same time, I have brought every department of it as near to the most recent discoveries, as my own ability and established truths would allow. How far I have succeeded in this the public must determine, I am answerable only for the will and the working; and I can only say that I have been hearty in the one and vigilant in the other.

ROBERT MUDIE.

Grove Cottage, Chelsea,
March 22nd, 1836.

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A COMPENDIUM

OF

NATURAL PHILOSOPHY.

INTRODUCTION.

OF THE GRADUAL IMPROVEMENT OF NATURAL PHILOSOPHY.

1. The Order observed in this Treatise.—2. The Method of philosophising among the Hebrews and Egyptians.—3. Among the Greeks :—The Philosophy of Pythagoras, Plato, Aristotle.—4. The different Method pursued by the four Greek Sects.—5. The Philosophy of the Schoolmen.—6. The Revival of Philosophy by Lord Bacon.—7. Greatly promoted by Philosophical Societies.—8. The general Improvement of Philosophy in modern times.—9. The Philosophy of the Heavens.—10. The Philosophy of Life and Growth.—11. The Philosophy of Material Substance generally.—12. The Progress of Chemical Science.—13. The Chemical Properties of Matter.—14. The general Action of Matter.—15. Modifications of this Action in Heat, Electricity, Galvanism, Magnetism, Motion, and Animal Life.—16. Of Spirits and Divine things.

1. Natural Philosophy treats both of God himself, and of his creatures, visible and invisible. Of these I purpose to speak in such a manner, as to proceed from the consideration of Man, through all the orders of things, as they are farther and farther removed from us, to God, the centre of all knowledge. (I mean, of visible things :—of

the invisible world we cannot know much, while we dwell in houses of clay.) Thus, speculative philosophy ascends from man to God; practical, descends from God to man.

2. The most ancient nations, the Egyptians and Hebrews in particular, philosophised much concerning God, and concerning Genii, good or evil spirits, of an order superior to man. What they taught concerning the visible world, related chiefly to its origin, the changes it was to undergo, and its final dissolution. But on all these heads, they only delivered to their posterity what they had received from their forefathers.

3. Among the Greeks, Thales Milesius and his followers applied themselves with great industry to discover, with the best helps they had, the natural causes of material things. They were succeeded by others, who more curiously searched into the structure of natural bodies. Here the foundation of natural history was laid, in various observations on plants, animals, and other things. And herein the endeavours of Aristotle and Theophrastus in particular are to be commended. Yet, in other respects, Aristotle did not promote, but rather obstruct, the knowledge of nature: for he made philosophy as unintelligible by his abstract and metaphysical notions, as Plato, Pythagoras, and others did, by their ideas, numbers and symbols.

4. In succeeding times, when the four Greek sects, the Platonic, Peripatetic, Epicurean, and Stoic, divided the western world, the Platonists almost confined themselves and their opinions to the subject of divinity; the Peripatetics regarded little but logic; the Stoics little but moral philo-

sophy; and the Epicureans had small concern about any, being immersed in sensual pleasures: so that none of them made any considerable improvement in any branch of natural philosophy.

5. When the utter barbarism which followed was a little dispelled, Aristotle began to reign. His followers (the schoolmen, as they were called) might have improved natural philosophy, if, like their master, they had diligently cultivated the knowledge of nature, and searched out the properties of particular things. But it was their misfortune to neglect what was commendable in him, and to follow only what was blameworthy: so as to obscure and pollute all philosophy with abstract, idle, vain speculations. Yet some of them, after the Arabians had revived the philosophy of more early ages, and introduced the knowledge of chemistry into Europe, were wise above the age they lived in; and penetrated so far into the secret recesses of nature, as scarcely to escape the suspicion of magic. Such were Roger Bacon and Albertus Magnus.

6. After the revival of learning, as all other branches of philosophy so this in particular received new light. None was more serviceable herein than Lord Bacon, who, well understanding the defects of the school-philosophy, incited all lovers of natural philosophy to a diligent search into natural history. And he himself led them the way, by many experiments and observations. It was not, however, in any particular branch of natural philosophy, and especially not in natural history, that Lord Bacon rendered so essential service to the cause of true knowledge. The grand improvement which he introduced was in the mode of philosophising, in arriving at the knowledge of

general laws, by the induction of particular and well established facts, and not in endeavouring so to twist facts, as to make them apparently support imaginary and often very absurd hypotheses.

7. Soon after this, not single persons only, but whole societies, applied themselves carefully to make experiments; that having accurately observed the structure and properties of each body, they might the more safely judge of its nature. And the advantages which have arisen from hence manifestly appear from the Memoirs of the Royal Society at London, of the Academy of Science at Paris, and those of the same kind in Germany, as well as several other parts of Europe. In later times, those labours in the field of science have been more numerous and crowned with more abundant success; and the discoveries both of the nature of particular substances and of the laws of general action which have rewarded these labours, have tended very much to improve all the arts of life, and add much to the comforts of society.

8. To detail all the particular, or even the general truths in natural philosophy which have been established in modern times; to describe the various instruments and apparatus by which the labours of the inquirer after natural truth have been abridged and perfected; or even to give a list of all the branches into which it has been found necessary to divide the field of nature, would far exceed the limits of these introductory remarks. We may mention, however, that in proportion as the subjects of natural philosophy have been more separated from each other in their details, the great principles that combine the whole together, and prove that all is the workmanship of one cre-

ating God, and under the government of one Heavenly Father, have been rendered more perspicuous.

9. One or two points in the leading divisions of the great subject of creation may just be mentioned, were it only for the purpose of showing how vast a field is open to every one who is inspired with the love of knowledge. In the philosophy of the heavens, and in the connection of that philosophy with matters which are familiar to us upon earth, Newton may be said to have fully established the general law. But in consequence of the improvement of telescopes for viewing distant objects, of measuring instruments—whether of lines, of circular arches, or of times—of the number of observers, and the correct agreement of their results, as tending to establish the general laws, it may now with truth be said that as the heavens are the most sublime, so it is the most intelligible page in nature's volume. Not only have the line and the balance been applied to all the systems of bodies that accompany our sun, but of very late years our more accurate observers are beginning to feel their way to the starry heavens.

10. In the knowledge of the living and growing parts of the material creation, the progress, though there are many more principles, and therefore much more difficulty than in the case of the heavens, has been very great. The different classes of animals have been arranged according to their structures; and as those structures are the instruments wherewith they work in whatsoever they do, this arrangement has become, not a mere list to burden the memory, but an instrument of philosophy, by means of which the knowledge of one

truth guides to that of many more. The opinion of the illustrious Harvey, that "every animal is from the egg," has been established in every case in which it has been possible to apply observation, either by the eye or the microscope; and thus, though the secret of life itself remains as much veiled from us as ever, we can trace its operation in the individual, from the earliest appearance of the germ to its final close. Nor has the knowledge of all the more important functions of life, and their different modifications in different kinds of living creatures, been less improved. The system of nutrition, by which the food is converted into chyle, the chyle conveyed into the blood, the blood sent to the lungs, in order to be purified by the vital air of heaven, and afterwards propelled over the body to renovate all its parts, and all their powers, has been clearly understood. So also the use of the function of breathing, which is necessary to every living creature when awake and in a state of activity, and, generally speaking, also during sleep, has been freed from almost all those sources of perplexity with which it was beset in the times of ignorance.

11. Nor have the labours of modern inquirers been less successful in examining the composition and nature of those substances which the ancients regarded as the elements of all things. The mechanical properties of the air have been more and more completely known, from the time that Galileo or Torricelli discovered its weight; the uses of its component parts have been more and more developed, since, at a period comparatively recent, namely, in 1774, Priestley discovered its composition. So also the discovery of hydrogen gas as

an element of water, by Cavendish, soon led to the knowledge of the composition of water; and of a vast number of important operations both of nature and in art, in which the composition or the decomposition of that important liquid is always concerned.

12. So very great indeed has been the growth of Chemistry, especially during the latter part of the eighteenth century, and the portion of the nineteenth which has elapsed, that it has become altogether a new science. Nor is it, like many of the sciences of the ancients, a mere matter of speculation in which men may be ingeniously occupied, and earn the empty name of being learned above their fellows. It is a practical science; and scarcely one discovery, certainly not one great discovery, has ever been made in it without bringing a reward, and an abundant reward, in real enjoyment to mankind.

13. Nor is the advantage confined to the details of particular sciences; for general science, which is but another name for natural philosophy, has become a witness for the Creator to the full extent to which it has been improved. The discovery that a vast many substances which were once considered as simple and elementary, are really compounds, of which the different parts exist in other substances very unlike in their general appearance and qualities, has led the way to a highly probable conclusion, though it is above human proof, namely, that the whole of material existence is ONE CREATION.

14. And great and important as is this conclusion, it is not the most wonderful. Matter as existent is an object of our senses. We can see

it with our eyes, and handle it with our hands. But,—independently of matter as existing, and independently of the Almighty Creator, the rational and immortal spirit of man, and of any other class of spiritual being that may exist,—there is *action* in matter. We can no more consider this action as a quality of matter, than we can suppose that matter created itself—which involves the absurdity of its existing before it existed, and is therefore as unphilosophical as it is impious. Thus we are led to the great First Cause as the source of the action of matter as well as of matter itself,—the Author of every form and of every change which matter can assume or undergo.

15. And it is worthy of remark that, in proportion as the several kinds or modifications of this action have been examined, they go to establish an essential oneness in it, similar to that which becomes more and more probable, the farther we inquire into the properties of material substance. Fire, which was of old looked upon as a material element, has been found to be only an accompaniment of certain kinds of action in matter, weak when the action is weak, and ardent when the action is more energetic. In all cases too, whatever be the substances of whose action it is the accompaniment, or whatever may be the nature and the consequences of that action, which we call *heat*, or when powerful enough in its display, *the cause of fire*, is in all cases exactly the same. In our common fires; in those mighty furnaces of nature, the volcanoes; in the beams of the sun when concentrated by a burning glass or a burning mirror; in the lightning of the cloud; in what we are accustomed to call the phenomena of mag-

netism; in motion, when sufficiently energetic; and in animal life: in all, in short, this cause of fire is one and the same, or capable of producing exactly the same effects, which is all that we know or can know of sameness in causes. Such are the two great laws, to which the study of natural philosophy, as improved in modern times, clearly and directly points. They are so simple, so sublime, so universal in their application, and so elevated, not only above our most enlightened understanding, but above our most awakened fancy, that they lead us clearly and directly to Him who sitteth on the zone of the universe, and in whose sight worlds and all their inhabitants are but as grasshoppers.

16. What remains of natural philosophy, is, the doctrine concerning God and spirits. But, in the tracing of this, we can neither depend upon reason nor experiment. Whatsoever men know, or can know concerning them, must be drawn from the oracles of God. Here, therefore, we are to look for no new improvements, but to *stand in the good old paths:* to content ourselves with what God has been pleased to reveal; with *the faith once delivered to the saints.*

PART THE FIRST.

OF MAN.

CHAPTER I.

OF THE STRUCTURE OF THE HUMAN BODY.

1. The similar, solid Parts.—2. A Fibre.—3. The Cellular Membrane.—4. A Bone.—5. A Cartilage.—6. A Membrane. —7. Arteries.—8. Veins.—9. Lacteals and Lymphatics.— 10. Glands.—11. Muscles and Tendons.—12. The Skin.— 13. Pores and Perspiration.—14. The dissimilar Parts, in particular the Head, Cerebrum, Cerebellum, Medulla oblongata —15. The Meninges, or Membranes of the Brain.—16. The Brain.—17. The Origin of the Nerves.—18. The Pineal Gland.—19. The Guards of the Eye.—20. Muscles of the Eye; Tunica adnata; Structure of the Eye.—21. The Coats of the Eye.—22. Humours of the Eye.—23. Peculiarities relative to them; Account of a person couched.—24. The external Parts of the Ear; the internal, particularly the Drum. —25. The Bones, Passages, Windows, Labyrinth.—26. The Nostrils.—27. The Tongue, and Teeth.—28. The Palate and Organs of Speech; Voice in different Animals.—29. The Hair and Nails.—30. The Heart and Circulation of the Blood.—31. The Lungs, and Respiration.—32. The external parts of the Middle Cavity.—33. The Stomach.—34. The Intestines and Mesentery.—35. The Lacteal Vessels.—36. The Omentum Peritoneum, Pancreas.—37. The Liver, Gall-bladder and Ducts.—38. The Spleen.—39. The Kidneys, Ureters, Bladder. —40. The Hands and Feet.—41. The Fluids of the Body. —42. The Blood.—43. Animal Heat.—44. Reflections.

1. As man ought to know himself best, we begin our Treatise here. And first, let us contemplate the structure of the Human Body. The parts of

this are either solid or fluid. The solid parts, or those which are not liquid, whether hard or soft, of which the organs of the body are made up, may be termed *similar* parts, because they are found of the same texture and substance in different situations, and in organs applied to different uses. Of this description are fibres, bones, ligaments, muscles, tendons, arteries, veins, and other vessels; and also the general coverings of the body, the scarf skin, or *epidermis*, the mucous tissue, or *rete mucosum*, the true skin, or *dermis*, and the cellular membrane.

2. A Fibre is a kind of slender thread, of which all the other parts of the body are woven; according to the difference of which, the substance of the fibres is different also.

Earthy substances, considered as elementary in the human body, are composed of small particles, so minute indeed, that they appear to be capable of forming a colourless compound with water, and probably also of floating in the air. These form the basis of the bones or hard parts of the human body; and all the rest of the solids are made up of soft parts, and are called animal matter. The earthy part is, generally speaking, salts of lime.

These earthy particles have their connexion and power of cohesion not from themselves or by mere contact, but from the intermediate glue interposed between them.

This glue which is the general cementing substance in all the solids of the body, both hard and soft, is called gelatine, and it is found in the chemical analysis of bones, as well as from many other parts of the bodies of men and animals. It, and all the parts which are purely animal matter, can be decomposed by the heat of a common fire, while, in the case of a bone, when burnt to a pure white, the lime remains, in the shape of the bone, but it is brittle, and without any gloss. On the other hand, if the bone is steeped long enough in an acid, the lime is destroyed, and the animal matter left behind, in the shape of the bone, but flexible like a gristle.

Earthy particles then, cohering longitudinally, and tied together by an intervening cohesive glue, compose first one of the least or most simple fibres, such as we have a knowledge of, rather from reason than sense.

The finest microscopes have been hitherto insufficient to lead us to a sight of the smallest moving and nervous fibrils, and still less can we ever expect from them to get any sensible idea of the mechanism by which sensation and motion are effected.

But the least fibres which appear to the sight, are of two kinds.

From these two kinds of fibres as we shall presently see, we may distinguish the former by the title of filamentary, and the latter of membranous.

The first kind of these fibres is lineal, namely, such a form as makes their length considerably large in proportion to their breadth; and which, by disposing of the elementary particles in a right line, must of course lay them generally parallel to the neighbouring or contiguous fibres. Examples of such fibres we see in the bones, and most easily in those of a fœtus; and likewise in the tendons, ligaments, and muscles; only we must here always remember, that the eye never reaches to the smallest fibres but to larger ones made up of the smallest, and like to them in slenderness, placed together in a rectilineal course. That these are not different from the smallest fibres, we are persuaded by the most accurate microscopic observations that have been made, by which, the muscular fibres divided even to the last, appear similar to the larger, till, at length, they seem mere lines, like spiders' threads.

The second kind of fibres are those which are conjoined with a breadth frequently larger than their length; and the parts composed of these are usually called membranes.

From what has been said, we may admire nature no less for her wise economy than simplicity, in thus forming all that variety of parts we see in an animal, from one simple mass of clayey or slimy matter compounded of earth and glue; from whence the body is not only augmented from a single point in the ovum, to its full growth and stature; but like the timbers of a ship, is also every day repaired during life, until at length, not two jots of the old or first materials remain. This renovation of parts is made slower in some constitutions, and in some organs, than in others. How quickly the animal juices, and also the hair, nails, &c. are renewed, every one knows; and we may venture to say, that once in three years, the change is universal; at the end of which time, though a man remains the same identical person, he is not the same matter.

3. But we proceed from these simple fibres to the next least compounded solid which they compose,—the cellular web-like substance.

This is made up partly of the simple fibrils, and partly by an infinite number of little plates or scales, which, joined in various directions, intercept small cells and web-like spaces; and by extending round every, even the least, moving solid part of the body, conjoins them all together in such a manner, as not only sustains them, but allows them a free and ample motion.

The extension of this substance, not only with the skin round the whole body, but also round every viscus or organ, and round every individual moving fibre or vessel of them, into the cavities of the bones, and even the substance of the brain and its medulla, is a modern and wonderful discovery. This substance in its ultimate state being composed of simple membranes, when compacted and convoluted, gives birth to the least or most simple vessels, which again reflected through plates of the same substance compacted together, make compound and vascular membranes, to the consideration of which we next proceed.

Out of this cellular substance, compacted by a concretion of the membranous plates or partitions, and pressed together by the force of the incumbent muscles and distending fluids, arise other broad and flat plates or skins, in various parts of the body, which being generally disposed in one and the same direction, seem to have a better right to the name of membrane than the former; and these being convoluted into cones and cylinders, pervaded by a flux of some juice or liquors brought to them, put on the name of vessels; or else, being extended round some space that is in a plane parallel of itself, we call it a tunic or coat.

This cellular substance in the human body is found throughout the whole; wherever any vessel or moving muscular fibre can be traced; and this without the least exception, that I know of, in any part whatever. But so far as ever we can trace, it hardly ever admits of any fat into the cells; which are rather moistened by a watery vapour somewhat oily, exhaled out of the arteries and received again into the veins or the lymphatics.

Its plates or scales are still more loose and open where it invests the muscles and all their fibres (even to the ultimate fibre); and likewise where it surrounds and sustains the least vessels with their free motion. That within the cavity of the bones is also made up of bony plates, with membranous ones intermixed; and, lastly, it is the most loose and open of all, round the surface of the body on all sides, betwixt the muscles and the skin.

Through this cellular substance, the small vessels are spread and ramified in all parts of the body, from whose arterial extremities the fat is deposited into the cells, and afterwards absorbed by the orifices of the veins. This passage from the arteries, into the adipose cells, is so free and short, that there must needs be very large mouths by which they open, and by which they give admittance to injected mercury, air, or water. The oily fat, in this substance, is separated and expelled from the artery, not by any long ducts, but by transuding on all sides through the whole extent of the vessel. How quickly it is collected from the arteries, appears from the speedy renovation of it, by a returning fatness after acute diseases.

With regard to the sponge-like communications of this substance, it is remarkable that the intervals or spaces betwixt the plates or scales that make up their sides in the cellular membrane, are everywhere open, and form one continuous cavity throughout the whole body.

That out of this substance, joined with vessels, nerves, muscular and tendinous fibres (a great part of all which are before formed of this substance only), all their viscera, all the muscles and glands, with their ligaments and capsules, are entirely composed; and that only from the different length, tension, quantity or proportion of this, the diversity of our glands and viscera arises; and lastly, that this alone makes up by far the greatest part of the whole body, we are certain, if the whole be not formed out of the cellular filaments of this kind.

4. The hardest part of the body, white and void of sense, is termed a bone. The bones are covered with a thin skin, called the periosteum, which is extremely sensitive.

The bones consist of thin plates, lying one upon another; and these again, of fibres running lengthways, some to the extremity of the bone, some not so far. Yet none of them terminate there, but are continued transversely, and, as it were, arched, the fibres of one side meeting and uniting with those of the other, and this at each extremity.

These plates are differently disposed in different bones: in those that have a large cavity, they are contiguous on each side, and very closely united. In those whose cavities are small, many of the inner plates are distant from each other, having little long cells between them. In bones whose plates are contiguous, there are pores through and between them, besides those for the blood-vessels. The first pierce them transversely, from the cavity to the external surface of each plate. The second run lengthways between the plates, and diffuse an oil, with which they are supplied by the transverse pores.

The bones are generally bigger at each end than in the middle, that the joints may be firm, and the bones not so easily dislocated. But to strengthen the middle of the bone, the fibres there are more closely compacted. Likewise the bone, being large and hollow, is not so easily broke as if it had been solid and smaller; for of two bones of equal length and equal number of fibres, that is stronger which has the larger diameter.

The blood-vessels usually enter the ends of the bones, the arteries at one end, the veins at the other. The medullary vessels commonly enter the sides of the bone, and that obliquely.

The marrow is covered with a membrane, wherein are enclosed little bags. In these bags are glandulous bladders, serving both to secrete the marrow from the blood, and to receive it. Both these and the bags have passages into each other whereby the marrow has free course. It passes first through the transverse pores of the first internal plate into the longitudinal ones. Thence it proceeds into other transverse pores, when it alters its course again, and exudes farther. Thus it passes alternately through and between the plates, until it is diffused throughout. In this manner it is diffused through bones, whose plates are contiguous. But where the plates are at a distance, the small cells contain glands, which directly supply the plates with marrow.

In the fœtal, or infant state, the marrow is a bloody serum, rather than an oil, but it becomes more fatty and consistent as the body advances to maturity. Its principal use appears to consist in rendering the bones less dry and brittle.

Besides the marrow, which serves as an internal oil for the bones, there is peculiar fluid for lubricating the joints, called synovia, and sometimes 'joint oil." It is secreted by little mucous bags, prepared for the purpose. It is nearly transparent, glairy, something like the white of an egg, and saltish to the taste.

The back bone hath these two things peculiarly remarkable: First, its different articulations from the other joints of the body. For here most of the joints are flat, and withal guarded with asperities and hollows, made for catching and holding; so as firmly to lock and keep the joints from luxations, but withal to afford them such a motion as is necessary for the incurvations of the body.

Secondly. The difference of its own vertebræ, or joints, in the neck, back, and loins. In the neck the two upper vertebræ are curiously made, and jointed (differently from the rest) for the commodious and easy bending and turning the head every way. In the thorax and back, the joints are more close and firm; and in the loins more lax and pliant; also the knobs and sockets are turned a quite contrary way, to answer the occasions the body hath to bend more there than higher in the back. So that its structure is the very best that can be contrived; for had it been all bone, we could have had no motion in our body; had it been two or three bones articulated for motion, the medulla spinalis, the spinal marrow, or spinal cord, must have been necessarily bruised at every angle or joint; besides, the whole would not have been so pliable for the several postures we have occasion to put ourselves in. If it had been made of several bones without intervening cartilages, we should have had no more use of it than if it had been but one bone. If each vertebra had had its own distinct cartilage, it might have been easily dislocated. And lastly, the oblique processes of each superior and inferior vertebra, keep the middle one, so that it can neither be thrust backwards nor forwards to compress the medulla spinalis.

The pelvis made in the belly by the ilium, ossa coxendicis, and pubis, is larger in a female than in a male skeleton, that there may be more room for the lying of the viscera and fœtus. So the cartilage bracing together the two sharebones, is twice thicker and laxer in women than men. As also is the cartilage that ties the os sacrum to its vertebra; and all to give way to the passage of the fœtus.

Another considerable difference is in the cartilaginous production of the seven long ribs, whereby they are braced to the breast-bone. These are harder and firmer in women than in men; the better to support the weight of the breasts, the sucking infants, &c.

It is remarkable in the joints, and a manifest act of caution and design, 1. That although the motion of the limbs be circular, yet the centre of that motion is not in a point, but an ample superficies. In a point the bones would wear and penetrate one another, and the joints would be exceedingly weak. But the joint consisting of two large superficies, concave and convex, some furrowed and ridged, some like a ball and socket, and all lubricated with an oily substance, they are incomparably prepared both for motion and strength. 2. That the bones next the joints are not spongy, as their extremities commonly are, nor hard and brittle, but capped with a strong, tough, smooth, cartilaginous substance, serving both for strength and motion.

The joints or articulations of the bones display a great variety of forms, according to the kinds of motion which they require to have. Sometimes they are simple hinges, at other times they are balls and sockets, and sometimes again they have a sort of double motion, so that the limb is bent upon one part of the joint, and has a rolling motion upon another. It is a beautiful contrivance in all animals which bear the weight of the body upon the feet, that none of the bones of these are articulated directly on the vertebræ of the spine, especially in the upper part of the human body, and the fore-part of those animals which walk on all-fours. By this means, the brain, which is lodged in the skull, and continued in the spinal column, is not subject to any shock or concussion in the motions of the animal. Besides this, the feet of leaping animals are so furnished with cartilage, and have their joints so fashioned, that they yield like so many springs.

That the nourishment taken in is continually conveyed through the bones, as well as the flesh, appears from an easy experiment. Mix red liquor with the food of any animals, and in short time their bones are dyed red. When madder root was mixed with the food of a cock, which died after sixteen days, all his bones were red, the internal parts as well as the external; and the most solid parts were the most deeply tinctured; in swine, the teeth above all the rest.

5. Annexed to the bones are the cartilages, white, flexible, and smooth; many of which in process of time become bones, hard and quite void of sense.

A cartilage is an elastic substance, uniformly compact and somewhat transparent, harder and more brittle than a ligament, softer than a bone. It is covered with a fine membrane, folded over the bone from where the ligament is inserted. Every joint is invested with a membrane, which forms a complete bag, and covers every thing within the articulation. The blood-vessels are so small that they do not admit the red globules, and are demonstrable only in very young subjects. All round the neck of the bone, there are numerous arteries and veins which spread into smaller branches and communicate with each other. These divide into still smaller branches on the adjoining surface, as they run toward the centre of the cartilage. We can seldom trace them into its substance, because they end abruptly at the edge of it. The larger vessels plunge in by numberless small holes, and disperse themselves into branches between the cartilage and bone. From these again there arise many short small twigs, which shoot towards the outward surface. This distribution of the blood-vessels is very peculiar, and calculated for obviating great inconveniences. Had they run on the outward surface, the pressure and motion of the two cartilages must have occasioned frequent obstructions and inflammations. But by creeping round the cartilaginous brim, where there is little friction, or under the cartilage where there is none, they are perfectly well defended from all such accidents.

Cartilages are admirably contrived for all the purposes of motion. By their uniform surface they move upon one another with ease: by their soft, smooth, and slippery surface, mutual abrasion is prevented. By their flexibility, the contiguous surfaces are constantly adapted to each other. By their elasticity the violence of any shock, which might happen in running, jumping, or the like, is broken, which must have been extremely pernicious, if the hard surfaces of bones had been immediately contiguous. The cartilaginous fibres appear calculated chiefly for this last advantage. To conclude, the insensibility of these cartilages is no less wisely designed, that by this means the necessary motions of the body may be performed without pain.

6. The various parts of the body are clothed with membranes, which are whitish tunicles, extremely thin and flexible, composed of fibres interwoven with each other, as a piece of cloth is of threads. They are fastened together by a kind of cartilages, which are termed ligaments.

7. An artery is a hollow canal, composed of fibres closely twisted together, which conveys the blood from the cavity of the heart to all the parts of the body. All the arteries spring from two, the aorta or great artery, and the pulmonary artery. The latter conveys the blood from the right ventricle of the heart through the lungs, into the left ventricle. The former conveys it from the left to all other parts of the body; for this reason it is called the systematic artery, and the left side of the heart is called the systematic side.

The tubes of the arteries are composed of several layers or coats, some of which are membranous, and others muscular. The inner coat is a membrane, very thin, fine, smooth, and transparent, but at the same time very firm and strong. Immediately external of this is situated the fibrous or muscular coat, which is very conspicuous in the larger arteries, but in the smaller ones it is less apparent. The fibres of this coat form arches, which embrace it on all sides, but not in perfect circles. These muscular fibres are of a reddish yellow colour, and when numerous they render the vessels opaque. It is in this muscular coat that the power of contraction in the artery resides. The third or external coat is composed of membrane, or of a portion of the cellular membrane in which the arteries are embedded. Portions of this kind of membrane unite all the coats together, and also join the artery to the surrounding parts in such a manner as that, while its proper motions are left perfectly free, it is kept in its proper place. The provisions which are made for securing the action of the arteries, while the parts in which they are situated perform their necessary motions, are often beautiful displays of wisdom in design.

All the arteries begin with a larger trunk, and grow less and less till they are no longer seen by the naked eye. Hence they are continued, until they inosculate with the veins, and so form one uninterrupted channel.

They appear yellowish, because their coats are of so dense a contexture that the blood is not visible through them. The blood thus proceeding from wider to narrower canals, is continually obstructed in its passage; but being pushed on from behind by the action of the heart, it distends the coats, and causes that leaping motion called the pulse. By this, as well as by their pale colour arteries are distinguished from veins.

The pulse of a healthy person, rising in the morning, beats 65 in a minute; but after the fatigue of the day, it will in the evening beat 80 in that time; and again, by the night's rest or sleep, it will become less frequent, until in the morning you will find it return to 65. For the voluntary motions of the muscles and actions of the external and internal senses, urge the venous blood on to the heart, which, being thereby oftener stimulated, makes more frequent contractions. This is the cause of those paroxysms or fits of increase, observable in all fevers towards the evening. For sleep not only retards the motion of the blood, but of all the other functions and actions in the body.

It is one of the curious observations of Dr. Hales, that the pulse is quicker in small animals. He found the pulse of a horse slower by half than in a man, viz. 32 only in a minute; whereas in a dog, the pulse beat 97 in that time. And this we see is conformable to the blood's heat, measured by the mercurial thermometer of Farenheit's scale. For the blood in oxen, horses, and other large animals at rest, being five or six degrees cooler than in us, will not rise to our heat but by labour; whereas dogs, cats, and fowls, are five or six degrees hotter than we, viz. about 102; and the latter when sitting or brooding on their eggs for young are still four or five degrees hottér, viz. 107 or 108, which is commonly the heat of our blood in the fit of an ague; where it is observable, that during the greatest sense of cold chill, the blood is three or four degrees hotter than in health, after which it gains four or five degres more in the height of the hot fit, viz. 104 or 105 degrees; but in ardent fevers, where the pulse beats 140, the heat of blood will still be four or five degrees higher, viz. 110; that is two or three degrees more than equal to a brooding hen.

The pulse is more quick in children and becomes slower in persons as they grow older. The salient point of an ovum beats 134 in a minute. New born infants have their pulse 120, and from thence down to old age it grows slower, to 60 in a minute. A feverish pulse begins at 96 per minute; it is excessive at 130 or 140, which is the number of the pulse with which a person dies. The pulse beats slower in winter, and quicker in summer, by about ten strokes per minute; and under the torrid zone it grows quicker to 120.

The arteries always terminate in very small tubes, which are called capillaries, from their slender and hair-like appearance. The proper capillaries inosculate with the capillary commencement of the veins; and it is understood that they simply convey to these that portion of the blood which requires to be purified and renewed before it is again fit for the purposes of life. The others terminate in what may be termed exhalants, because they separate matters from the mass of the blood. Some of these open into cavities, and discharge liquids little different from those previously existing in the blood; others pass through peculiar organs called glands, which separate, secrete, or prepare the particular fluids for the different purposes of the body; and there are a few which convey their contents into cellular or spongy parts, from which it is again taken up by other vessels, without having undergone much change.

8. The veins are the counterparts of the arteries; for as the arteries convey the vital blood from the heart as the fountain of life to all the parts of the body, so the veins again bring it back to that fountain that it may be purified and renewed. The veins have three coats as well as the arteries; but their external cellular coat is looser, their

fibrous coat is weaker, and the fibres lie lengthways; and altogether, they have not the elasticity of the arteries, neither is there any pulsation in them. They are of larger diameter than the arteries; they are more numerous; and though generally two veins accompany the deep-seated arteries, there are veins much nearer the surface. The blood in the veins is darker-coloured than the arterial blood, and the coats are more transparent, so that the surface veins appear blue through the skin, while there is no means of discovering an artery except by its pulsation.

There are three principal trunks of the veins: the vena cava, which brings back the blood from the system, and pours it into the right, or pulmonic auricle of the heart; the pulmonary vein, which brings back the purified blood from the lungs to the left or systematic auricle of the heart; and the vena porta, which is connected with the liver, and is in some sort both an artery and a vein. It receives the return blood from the other viscera through small veins which unite into it as a trunk; and it branches into ramifications at the other extremity, by means of which the same blood is distributed through the liver. The liver also receives arterial blood by other vessels; but it differs from every other organ in the body in having a part of its supply, which has not undergone the renovating process in the lungs. This perhaps may account for the darker colour of the liver, and must answer some very important purpose in the functions of that organ; but to us these are mysteries.

9. Besides the arteries and veins, there are two sets of vessels which convey fluids through certain

parts of the body, or through most of it generally. These are the lacteals and the lymphatics.

The lacteals are so called because the fluid which they contain has some resemblance to milk. Their general purpose is to bring the nourishment from the digestive organs, to the thoracic duct, by which it is poured into the mass of the blood, before its returning current reaches the pulmonary side of the heart.

The lymphatics circulate that thin and watery juice which is known by the name of lymph. Some of them are near the surface, and others more deeply seated. They are very numerous, more so perhaps than both the arteries and the veins; but they are very minute, and as they and their contents are transparent, they are not observed without some difficulty.

Both lacteals and lymphatics pass through knots or knobs, which are called glands—a name which is rather puzzling as applied to any part of the animal structure. It means something like a nut, which, though it may be descriptive of the form of an organ, conveys no notion whatever of its use. The lacteal glands are all situated in the mesentery, or membraneous tissue to which the gut or intestinal canal is attached. The lymphatic glands are situated in many parts of the body, and vary greatly in size, some being as small as a grain of mustard seed, and others nearly the size of a walnut.

10. Besides those glands which belong to the lacteals and lymphatics, there are numerous other glands in the body; and a gland is generally understood to be an organ which prepares some new fluid, or otherwise changes some fluid which passes through it; but as these glands answer peculiar

and local purposes, the account of them belongs to that of the local parts, or of the functions which those parts perform. The liver is the largest gland in the body: and it is exceedingly important from its intimate connexion with the system of nourishment.

11. Muscles are the organs of motion. They are almost entirely composed of fleshy fibres, arranged for the most part parallel to each other, and forming a series of fasciculi, or bundles, which by their union form what is called the belly of the muscle. These fasciculi, as well as the fibres of which they are made up, are separated from each other by a cellular membrane, which serves to connect them together, and to favour the passage and distribution of the numerous blood-vessels, lymphatics and nerves, with which the muscles are supplied. The direction of these fasciculi is very various. Sometimes they run along the whole length of the muscle, in one rectilinear parallel range, as in the muscles that appear in the fore-parts of the belly, and the muscle is then called a straight muscle. Sometimes they run parallel to each other and in an oblique direction, forming what is called an oblique muscle. In some instances they are disposed on each side of a middle line, so as to form angles with each other, like the feathery parts of a quill, and the muscle is then called a penniform muscle. In a few instances they take a circular direction, forming an orbicular muscle, as that which surrounds the eye. Of these, the oblique muscles are the most frequent.

Many of the muscles terminate in strong pearl-coloured bodies, which are tendons, or, in common language, sinews. They are composed of the same kind of matter as the membranes, namely, of glue or gelatine. These tendons must not be confounded with the ligaments or ties which unite the bones, and also different parts of the body together; for these are fibrous, which the tendons are not; and they are remarkably strong and elastic, and are not softened or even much weakened by boiling.

12. The skin which everywhere surrounds the body, and serves as its general protection, consists of three parts: the epidermis, cuticle, or scarf skin, which is the outermost; the rete mucosum, or mucous tissue, which is immediately within the cuticle; and the cutis, or true skin, which is the innermost, and by far the thickest. Beneath these there is a portion of cellular membrane, but that does not strictly form part of the skin.

The cuticle is very thin, and in itself entirely destitute of sensibility. It consists of a substance resembling in its nature boiled white of egg, or as it is called, coagulated albumen. This substance does not melt in water; and one cannot help admiring the wisdom of design in applying such a substance as the covering of all animals. It is found not only in the skin properly so called, but in the appendages of the skin, the hair, and nails.

The mucous tissue consists of a very fine network of small vessels. It is upon this that the colour of the skin depends; and the colour which it possesses is natural to the individual and the race. It is reddish white in most Europeans, brown in gypsies, reddish in mulattoes, and black in negroes. In the latter, it can be changed to a white, by long bleaching in water containing hydrochloric acid; but in proof of the scripture declaration that "the Ethiopian cannot change his skin," it speedily turns black again. Some individuals of all races have the mucous tissue white; and these are called *albinos*, which means "whites." The particular odour given out by the skin, arises from this part as well as the colour. The true skin, which is much thicker than the others, and very thick on some parts of the human body, consists of fibres interwoven like the texture of a hat. It is formed in great part of gelatine or glue, but, in the living body, it contains many small blood-vessels, and has a high degree of feeling.

13. Under the skin lie the subcutaneous glands, which are supposed to transmit through the pores an insensible steam, commonly believed to be of the same kind with what, when sensibly thrown out, is called sweat.

The pores in our hands and feet are very remarkable. Survey with a glass the palm of your hand well washed, and you may perceive innumerable little ridges, of equal bigness and distance, every where running parallel with each other: these are very observable on the ends and first joints of the fingers and thumb, and near its root, a little above the wrist.

On these ridges stand the pores, all in even rows. Through a good glass, every pore looks like a fountain; the sweat may be seen to stand therein, as clear as rock water. The ridges are so placed, that they may better suit with the use and motion of the hand; those on the lower side of each triangle, to the bending in of the fingers; those on the other two sides, and on the elliptic ridges, to the pressure of the hand or fingers' ends against any body requiring them to yield to the right and left.

The pores are placed on these ridges, not in the furrows between them, that their structure may be less liable to be injured by compression, whereby the furrows only are dilated or contracted, the ridges constantly maintaining themselves, and so the pores are unaltered ; for the same reason, the pores are very large, that they may be the better preserved ; though the skin be never so much compressed and condensed, by the constant labour of the hand ; and so those on the feet, that they may be preserved, notwithstanding the compression of the skin by the weight of the whole body.

Through the pores there continually transudes a subtle vapour from every point of the body, being what redounds of the aliment, comminuted to the highest degree, and sent to repair every particle of it. And the matter thus evacuated, is more than is thrown out by all the other passages together.

A person of middle age found what he perspired was five-eighths of the food taken in ; so that there remained only three-eighths for nourishment and all other evacuations. He observed also, that as much is perspired in one day, as passes by stool in fourteen ; and more particularly that in a night's time, about sixteen ounces are usually thrown out by urine, four by stool, and about forty by insensible perspiration.

If a man eats and drinks eight pounds in a day, five pounds of it pass by perspiration, namely, about one pound within five hours after eating, (perspiration being least of all soon after eating) ; from the fifth to the twelfth hour, about three pounds, and from the twelfth to the sixteenth, scarcely half a pound. Exercise increases perspiration much. But it is naturally less in women than men.

While this steam flows from our body, it constantly imbibes a supply of moisture from the air, which serves to keep all its parts soft, pliant, and fit for motion. Hence, from the greater moisture of the air, we perspire less in winter than in summer, and in rainy weather than in fair. Live therefore, if possible, in a clean house, and in a pure, dry air.

This inhalation is very considerable. Dr. Keil found his body to have imbibed in one night eighteen ounces of moisture. And on a sudden change of weather from dry to wet, the inspiration sometimes exceeds the expiration, there being absorbent-veins, which accompany the numberless arteries from which the perspiration is discharged. To the matter thus imbibed (not the obstruction of the pores) he ascribes what we term a cold. Sweating cures this, by throwing out the noxious matter which was imbibed before.

The cutaneous vessels both exhaling and inhaling, are capable of contraction and relaxation by the power of the nerves. This appears from the effects of the passions, which if joyful, increase the circulation, and relax the exhaling vessels. Those passions, on the contrary, which are sorrowful, and retard the circulation, contract the exhaling vessels, as appears from the dryness and corrugation of the skin, like a goose skin, after frights; and from a diarrhœa caused by fear. But the same affections seem to open the inhaling vessels, whence the variolous or pestilential contagions are easily contracted by fear.

The benefits of insensible perspiration are so great, that life cannot be preserved without it. And the subtlety, equability, and plenty of what we perspire are the grand symptoms of health.

Fat, a whitish, oily substance, void of scent, is secreted from the blood, and lodged in small, oval, membranous bags, which shoot out of the arteries. It is found in various parts but chiefly under the skin, where (unless a man be emaciated) it runs co-extended with the skin over most parts of the body.

Fat is secreted from the arterial blood by the adipose glands, and transmitted again from the membranous cells to the blood through the veins. It seems to be a portion of the blood coagulated by the nitrous air mixed with it in the lungs. Artificial fat is made by mixing for some days oil of olives with spirit of nitre. Hence, divers animals grow fat in frosty weather, the air then abounding with nitre.

The uses of the fat are various, as to facilitate the motions of the muscles in all parts, lessen their attrition against each other, and prevent a stiffness or rigidity; it fills up the intermediate spaces between the muscles, in such a manner, with the cavities about many of the viscera, that it readily yields to their motions, and yet supports them when at rest; it serves as a stratum or bed to conduct and defend the vessels in their course to all parts; it gives an uniform extension to the skin, and serving as a cushion to ease the weight of the body in many parts, at the same time it renders the whole of a comely, agreeable shape: it probably by returning and mixing with many of the humours abates their acrimony; it has a principal share in forming the matter of the bile, and by transuding through the cartilaginous incrustations of the bones, it mixes with the articular liniment or synovia; also, by exhaling in a living person from the mesentery, mesocolon, omentum, and round the kidneys, it lubricates the surfaces of the viscera with an oily emollient vapour, and by interposing betwixt their integuments, prevents their growing one to another. The fat is laid up as a store to maintain the body when it has not sufficient food, or is incapable of feeding. In many animals also, it serves as a protection against cold, which is remarkably the case with those warm-blooded animals which inhabit the waters.

Yet too much fat is a real disease, which hinders the motion of the lungs, entangles the most active particles of the blood, and naturally creates dulness and heaviness. You may cure this by following three plain rules: eat and drink little; sleep little; work much.

14. The dissimilar parts are composed of the similar. The chief of these is the head. The cavity of the scull is nearly filled with a soft substance, termed in general the brain. But this is properly that part of it which lies forward. The hinder part (considerably smaller) is called the cerebellum. Under both, but chiefly the latter, and springing from the internal substance of both, is the medulla oblongata.

The skull is composed of two plates, one laid over the other. Between these is a spongeous substance, made of bony fibres detached from each plate. Hereby the skull is made not only lighter, but far less liable to fractures.

The skull is covered with a membrane called the pericranium. This has several holes, which give passage to the spinal marrow, the nerves, arteries, and veins. But these fill them so nicely that nothing can pass into or out of the head, but through these vessels.

It is round, that it may contain the more; but a little depressed and longish, advancing out behind and flatted on the sides, which contributes to the enlargement of the sight and hearing.

It is divided into pieces by four sutures. This makes it less liable to break, gives passage to the membranes of the pericranium, and vent to the matter of insensible perspiration.

15. All these are invested with two membranes, the inner (called pia mater) extremely thin; the outer (called dura mater) considerably harder and thicker. Where they involve the cerebellum, there is interposed between them the arachnoides, a very subtle and transparent membrane, which descending through the hinder part of the skull, together with them involves the whole spinal marrow.

16. The outer part of the brain, called the cortex or bark, is of an ashy or greyish colour. It is formed from the minute branches of the neighbouring arteries, which being wove together in the pia mater, inclose the inner part, ordinarily to the thickness of about half an inch.

It consists therefore of innumerable little glands, contiguous to each other, which are of themselves oval, but by their mutual pressure become angular and run waving with each other.

The inner part, called the medulla, is white, and terminates in another medullary substance, very white and hard, called the corpus callosum. The medulla is thought to consist of fine tubes, which when collected into little bundles, and covered with membranes, are termed nerves.

17. To trace this a little farther. From every point of the outer brain arise minute fibres, which in their progress uniting together, are easily perceptible. These constitute the substance of the inner brain and of the spinal marrow. In their further progress they are distinguished by coats detached from the two membranes of the brain into several bundles called nerves, resembling so many horsetails, each wrapt up in a double tunic.

Several of these part from the rest, in the brain itself, of which there are ten pairs; one on each side. From the spinal marrow there arise thirty pairs more. All these, while within the skull or the spine, are pulpous; but afterwards harden, acquire a coat, and spread through the smallest points of the solid parts of the body. Their coats are everywhere furnished with blood vessels, lymphatics, and vesicles of a very tight texture, which serve to collect, strengthen, and contract their fibres. And if we consider, 1. The great bulk of the brain, cerebellum, and spinal marrow (whereof the whole substance goes to constitute nerves, being continued into and ending in them). 2. The great number of nerves distributed hence throughout the whole body. 3. That the brain and spinal marrow are the basis of an embryo, whence the other parts are afterwards formed: and lastly, that there is scarce any part of the body which does not feel or move: it may seem not altogether improbable, that all the solid parts of the body are woven out of nervous fibres, and wholly consist of them.

18. The brain is divided into four ventricles. Near the rise of the fourth there is a round hole, over which is suspended the pineal gland, so called from its resembling the shape of a pine apple. It is furnished with veins and arteries, and inclosed in a thin membrane derived from the pia mater. Des Cartes imagined this to be the seat of the soul, but without any solid reason. Nor has any one yet been able to discover what is the use of it.

The brain is abundantly bigger in proportion in man than in other animals. In other animals, it is commonly biggest, cæteris paribus, in those that have most sagacity.

There are in the brain multitudes of vessels, so extremely small, that if a globule of blood (a million of which exceed not a grain of sand in bigness) were divided into 500 parts, those parts would be too large to pass through them. And these vessels are as large in the brain of a sparrow, as in that of an ox. Nor is there any difference between the brain of a large animal and a small, but that one contains far more of these vessels than the other. But the globules of the fluid passing through them are in all animals of the same size.

The outer part of a turkey's brain is a very clear and transparent oily matter. Innumerable fine blood vessels are spread through every part of this. And if a small part is cut there flows out a small globule of pellucid fluid.

The brain is not absolutely necessary to animal life. Infants have been born and lived some time without any. We have an authentic account from

Paris, of a child that survived the birth four days, not only without a brain, but even a head: instead of which it had a mass of flesh, somewhat like liver. In 1673, a child was born alive without any brain, cerebellum, or medulla oblongata; the skull being solid: nor had it any communication with the spinal marrow. Mr. du Verney took out the brain and cerebellum of a pigeon: yet it lived and walked about. Mons. Chirac took out the brain of a dog yet he lived. On taking out the cerebellum, he seemed dead; but revived when he blew into the lungs, and continued alive an hour. Many other instances are recorded, wherein, in different individuals all the parts of the brain have been found wanting; and some in which the entire contents of the skull have been reduced to a pulpy mass, apparently without organisation and without use. Thus it appears that no single part of this organ, or even the whole of it in the state in which it usually exists, is absolutely essential to the purposes of life.

Are there distinct provinces for the vital or spontaneous, and for the animal or voluntary actions? And does the cerebellum furnish the heart and other vital organs with nerves, while the brain supplies the nerves which go out to the organs of sense and voluntary motion? This is an elegant system, but is everywhere confuted by anatomy. From the cerebellum, the fifth pair of nerves is manifestly produced; but this goes to the tongue, to the muscles of the outward ear, of the eye, and of the nose, which are parts all of them either moved by the will or else destined to sensation. Again, from one and the same nerve there are vital branches sent to the heart and lungs, and others that are animal and voluntary to the larynx, or sensitive in the stomach. Lastly, the repeated accounts of injuries to the cerebellum, being so speedily fatal are not altogether true; for that both wounds and scirrhosities of this part have been sustained without any fatality to the patient, may be affirmed by certain experience.

This is the opinion advanced by the modern phrenologists, who attempt to account for the varied dispositions of different individuals of the human race, from the degree of development in different regions of the encephalon or general contents of the skull. But it is probable that structure has some effect, as the organs of the body are the instruments by means of which the soul, or intellectual part of man's nature has intercourse with the material world; yet the nature of that intercourse, and the means of communication between the immaterial mind and the material organ, are mysteries beyond the reach of human philosophy.

19. The eyes next offer themselves to our observation, guarded by the eyelids, eyelashes, and eyebrows. The eyelids consist of the cuticle, the skin, a thin expansion of the panniculus carnosus, and an inward coat. A pallisade of short, but stiff hairs grows out of their cartilaginous edge, both to break the too fierce impression of the rays of light, and to prevent any thing from getting into the eye, when open. These hairs only grow to a convenient length, and their points stand out of the way, those of the upper eyelids being bent upward, and those of the lower, downward. Meantime the eyebrows hinder sweat, or anything else which might be hurtful, from falling down from the forehead.

Both the eyelids are moveable, but chiefly the upper. Animals which have hard eyes, as lobsters, need none and therefore have no eyelids. But most brutes have an additional eyelid, called the nictitating membrane, which draws like a curtain, to wipe of what might incommode the eye. The monkey indeed has it not, as being furnished with hands like a man.

20. The eye can move upward, downward, to either side, and round, either toward the right or left. For these six motions, six muscles are allotted which spread their tendons far into the eye. At each inner corner of the eye, there is a gland with two or three ducts, which, opening on the inner surface of the eyelid, keep the eyeball moist, to facilitate its motion. By these glands tears also are secerned. The eye is connected with the surrounding bones by the tunica adnata, commonly called the white of the eye: in the midst of which is a large hole for the tunica cornea, through which the iris and pupil appear. The whole ball of the eye rises from the optic nerve, and is formed of three coats, propagated from it, and as many humours: two of which have each a coat of its own also. The eye therefore has five coats in all: three common, and two to contain their several humours.

21. The outermost coat proceeding from the dura mater, and surrounding the whole eye, is termed the sclerotica: the fore-part of it being transparent like horn, is thence styled the cornea. This is more convex than the rest of the eye. It is composed of several parallel plates, which are nourished by many blood vessels, but so fine as not to hinder the smallest rays of light. It has

an exquisite sense, that on the least touch of any thing, the tears may be expressed, to wash off any filth, which by adhering to it might render it dim or cloudy. The rest of the sclerotica is opaque, and of the same colour with the dura mater.

The second coat is called uvea. It is much thinner than the former, though thicker than the pia mater, from which it proceeds. In the forepart it is a round hole, which with, the crystalline humour interposed, constitutes the pupil, surrounded by the iris so named, from its supposed resemblance to the colours of the rainbow. The third and inmost coat is termed the retina. It is extremely thin and soft, and darker coloured than the lower part of the optic nerve, of which it is a continuation.

"If it be questioned," says Dr. Haller, "whether the object is painted upon the retina or upon the choroides? We answer, this last supposition is inconsistent with known observation, by which the retina is evidently a most sensible expansion of the nerve, while the choroides has only a few nerves, with small vessels, which are certainly blind. It is also opposed by the great variety of the choroides in different animals, while the constant uniformity of the retina is equally remarkable; to which add the black membrane, that is interposed betwixt the retina and choroides, in some kind of fish. Finally, anatomy demonstrates, that the choroides is seated in the blind part of the eye, but it is of itself of a white colour."

The fact of seeing, and the mechanical structure of the eye, as we are capable of observing it, are very different matters. When a recent eye is held up to the light, we see an inverted image or picture upon its retina; but how this picture contributes to the perception of visible objects, or whether it contributes to this at all, is a matter which we are incapable of explaning. That none but a perfect eye can see is true; and that there is a distinct sight in each eye is also true; because if we press the eye ball to a side we see double; and it is remarkable, that the second and fainter representation which we see by means of the eye which is pressed out of it natural direction, separates from the more perfect one seen by the undisturbed eye in the opposite direction to that in which the disturbed eye is turned.

32. The aqueous humour, resembling the colour and consistence ef water, lies in the fore-part of the eye, just behind the cornea: its interior surface is convex, the other a little concave. Whence this humour is derived we cannot tell, but its source must be plentiful: for if the coat containing it be so wounded, that all the humours run out, it needs only to keep the eye close for a season, and the wound will heal and the humour recruit.

Indeed, an eminent Italian affirms, that he has slit the pupil of divers animals and squeezed out all the humours and has afterwards restored them perfectly to sight: nay, that the eyes of many, instead of being damaged thereby, seemed more lively and vigorous than before.

The second humour, termed (improperly enough) the crystalline, consists of many thousand filaments, tending from the circumference to the centre, and closely woven together. It is a little convex before, and more behind. It serves to refract the rays of light so that they may meet and form an image on the bottom of the eye. It is set in the fore-part of the vitreous humour, like a diamond in its collet, and is retained there by a membrane that surrounds it, thence called its capsula. It is towards the outside like a jelly, but toward the centre as hard as salt. The figure of the outer part is varied by a ligament annexed, which can make it either more or less convex, or move it to or from the retina. And this is absolutely necessary in order to distinct vision : for as the rays of distant objects diverge less than those of near objects, the crystalline must either be made less convex or be set farther from the retina.

When dried it appears to consist of a vast number of thin round scales one upon another, 3000 of which have been counted in one crystalline. Each of these consists of a single fibre, wound this way and that in a stupendous manner, so as to run several courses and meet in as many centres, and yet not interfere or cross in any place.

The third, which is termed the vitreous humour, is not unlike melted glass. It is covered with an exceeding thin coat. The fore part is concave, as receiving the crystalline ; the other side is convex.

The whole apparatus of the eye tends to this, that there be produced in the bottom of, a distinct collection of all the rays, which, proceeding from any point of an object, penetrate the crystalline humour, that so an image of that object may be painted there. In order to this, the rays striking on the cornea, are reflected toward the perpendicular, and thus directed through the pupil to the crystalline. Meantime the iris, contracting or dilating the pupil, admits fewer or more rays, as the object is more or less vivid.

Now the flatter the cornea is, the fewer rays does it collect and transmit to the crystalline, and those more diverging. The rounder it is, the more rays does it collect and transmit, and those more converging. It is too flat in old men; it is too round in them that are short-sighted. The rays transmitted through the pupil to the crystalline humour, are there refracted anew, collected and rendered converging, and those that come from the same point are thrown in one point on the bottom of the eye. But if the crystalline be too dense, the focus or point wherein they unite will be too near: if that be not dense enough, it will be too remote. And this is another cause of short-sightedness, or the contrary defect.

In all vision both the eyes are used at once. And both together, as any one will find upon trial, behold an object in another situation than either of them apart would do. Hence a gentleman who had one of his eyes struck out, for some months after was apt to mistake the situation of things: and when he attempted to pour liquors into phials, often poured them quite beside the neck of the phials.

Two eyes greatly contribute, if not to distinct, at least to extensive vision. When an object is placed at a moderate distance, by the means of both eyes we see a larger share of it than we possibly could with one; the right eye seeing a greater portion of its right side, and the left eye of its correspondent side. Thus both eyes in some measure see round the object; and it is this that gives it in nature that bold relievo, or swelling, with which they appear, and which no painting, how exquisite soever, can attain to. The painter must be contented with shading on a flat surface; but the eyes, in observing nature, do not behold the shading only, but a part of the figure also, that lies behind those very shadings, which gives it that swelling which painters can never fully imitate.

There is another defect, which either of the eyes, taken singly would have, but which is corrected by having the organ doubled. In either there is a point which has no vision, so that if one of them only is employed in seeing, there is a part of the object to which it is always totally blind. This is that part of the optic nerve where its vein and artery run; that point of the object that is painted there must continue unseen. To be convinced of this we have only to try a very easy experiment. If we take three black patches and stick them upon a white wall about a foot distant from each other, each about as high as the eye that is to observe them; then retiring six or seven feet back, and shutting one eye, by trying for some time we shall find, that while we distinctly behold the black spots that are to the right and left, that which is in the middle remains totally unseen. When we bring that part of the eye, where the optic artery runs, to fall upon the object, it will become invisible. This defect, in either eye, is corrected by both, since the part of the object that is unseen by one will be distinctly perceived by the other.

The form of the eye is the most commodious which can be imagined. It is fittest both to contain the humours within, and to receive the images of objects from without. Was it square, or of any multangular form, some of its parts would lie too far off, and some too nigh those lenticular humours, which by their refractions cause vision. But by means of this form, the humours are fitly placed to perform their office of refraction, and the little darkened cell neatly adapted to receive the image of the object.

Again. As it is necessary for the eye to move various ways in order to adjust itself to various objects, so by this figure it is well prepared for such motions, and can with ease direct itself as occasion requires.

No less commodious is the situation of the eye: in the most eminent part of the body, and near the most sensible part, the brain. By its eminence in the body, it can take in the more subjects; and by its situation in the head, besides its nearness to the brain, it is most conveniently placed for defence and security; in the hand it might have been more ready for service, but to how many dangers would it have been exposed? The same may be said as to its site in any other part but where it is. But the head is a part that seems contrived and made chiefly for the use of the principal senses.

23. The power which the human body has of accommodating itself to the privation of any one of the senses is truly wonderful; and hearing and touch can, to a very great extent, compensate for the loss of sight. The late Dr. Henry Moyes, a popular lecturer on Natural Philosophy, though he had been blind from about four years of age, not only explained the doctrines of light and colours with great precision, but was very expert in mechanical operations, and could feel even different tints of colour by the touch of his fingers. John Metcalf, of Derbyshire, who became blind early in life, at last became an engineer of roads in a peculiarly difficult counntry for such a purpose, namely, the Peak of Derby. Sanderson, though

blind, discharged his duties with remarkable ability as Professor of Mathematics in Cambridge; and so delicate was his sense of touch that, in passing his hand over a cabinet of medals, he could distinguish the genuine ones from the counterfeits. So well indeed is the power of other senses to supply the vibration of sight now understood, that schools for the blind are general in the larger towns; and it is worthy of remark, that they who are deprived of this, the most apparently cheerful of all the senses, are remarkable for the cheerfulness of their own dispositions.

Yet blind persons, even though they distinguish them by the touch, have no idea of visible objects. Thus the gentlemen couched by Dr. Chesselden: add to this, that he had no idea of distance, but imagined all the objects he saw touched his eyes, in the same manner as those he felt did his skin.

An extract from Dr. Chesselden's account of this person, will not be unacceptable to the curious.

"This young gentleman could in a strong light distinguish black, white, and scarlet. Yet the faint ideas he had of them before he was couched, did not suffice to make him know them after. He now thought scarlet the most beautiful of all colours. Of others, the most gay were the most pleasing. But the first time he saw black, he was very uneasy; yet after a while he was reconciled to it. When he first saw, no objects were so agreeable to him, as those that were smooth and regular: although he knew not the shape of any thing, nor could distinguish one from another, either by its shape or size. Being told what those things were, whose forms he knew by feeling, he would carefully observe that he might know them again. Thus having often forgot, which was the cat, and which the dog, he was ashamed to ask: but catching the cat, which he knew by feeling, he looked at her steadfastly, and said, 'So, puss, I shall know you another time.' He was surprised, that the things or persons he liked best, did not appear most agreeable to his sight, expecting that what was most pleasing to his other senses, would be so to his sight also.

"We thought he soon knew the nature of pictures, but found afterward we were mistaken; for it was two months after the operation, before he discovered that they represented solid bodies. Even then he was no less surprised, expecting they would feel like the things they represented. He was amazed, that those parts which by their light and shade appeared round and uneven, should feel like the rest, and asked, which was the lying sense, feeling or seeing? Being shown his father's picture drawn in miniature, and told what it was, he acknowledged the likeness; but asked, how it could be, that so large a face should be contained in so little room? Saying it would have seemed as impossible to him, as to put a bushel of anything into a pint. But even blindness he observed, had this advantage, that he could go anywhere in the dark, better than those that could see. And after he was couched, he did not lose it, but could go all about the house without a light. Every new object gave him new delight, such as he wanted words to express. He was particularly delighted when he first saw a large prospect, and called it a new kind of seeing. Being afterwards couched in his other eye, he said, that objects appeared larger to this eye, though not so large as they did to the other when it was newly couched. But looking on them with both eyes, they seemed twice as large as if he looked with that only."

24. We proceed to the ear, formed with exquisite wisdom for the reception of sounds. The outward ear, consisting of an oval cartilage, externally convex, concave within, leads by various windings to the meatus auditorius, which is first cartilaginous, and then bony. It is filled with a viscid matter, called the ear-wax, which is supplied from vessels placed in the skin, surrounding the meatus, to hinder any hurtful animal from creeping into the ear. The meatus is closed within by a thin, dry, transparent membrane, affixed to a bony circle, which is called the membrana tympani. Behind it is that cavity of the os petrosum, which is termed the drum.

The outward ear has two parts, that which stands out from the head, called the auricle, and the narrow passage which enters the skull, called meatus auditorius.

The auricle is furrowed with divers winding canals, which receive and collect the various undulations of the air. They who have lost this, hear very confusedly, unless they use a trumpet, or form a cavity round the ear with their hands.

It is a wise provision, that the substance of the auricle is cartilaginous. Had it been bone it would have been troublesome, and might by many accidents have been broken off. If flesh, it would neither have remained expanded, nor so well have received or conveyed the sounds. Rather, it would have blunted them, and retarded their progress into the organ. But being hard, and curiously smooth and winding, sounds find an easy passage, with a regular refraction, as in a well-built arch.

It is observable, that in infants in the womb and newly born, the meatus auditorius is close shut up, partly by the construction of the passage, and partly by a glutinous substance, whereby the drum is guarded against the water in the secundine, and against the injuries of the air as soon as the infant is born.

It is remarkable that, in the ear of most, if not in all animals, where the meatus auditorius is long, ear-wax is constantly found. But in birds, whose ears are covered with feathers, and where the drum lies but a little within the skull, no ear-wax is found, because none is necessary to ears so well guarded and so little tunnelled.

25. In the internal cavity of the ear, besides a little branch of nerves, there are four little bones, two passages, and two windows. Three of those bones, from some imagined resemblance, are styled the hammer, the anvil, and the staple: the fourth is termed the orbicular bone. These are fastened by strong ligaments to each other, and to the neighbouring parts. The passages go from the side of the drum: one of which, termed the labyrinth, by a very winding way, carries a part of the auditory nerve to the external muscles of the head. The other passes from the bottom of the drum to the palate; whereby not only air, if needful, may be received, but the defect of hearing in some measure supplied by speaking to the mouth.

The labyrinth contains, besides the entrance, three bony, semicircular cavities, and a bony canal, in the form of a screw, divided into two parts, from the top to the bottom. The labyrinth is lined throughout with a thin membrane, furnished with veins, arteries, and nerves; and this membrane may not improbably be the organ of hearing.

The curious structure of the labyrinth and screw tend to make the weakest sounds audible. Those canals, by their winding, contain large portions of the auditory nerve, upon every point of which at once the sound being impressed becomes audible; and by their narrowness the sounds are hindered from dilating, which must have weakened them proportionably.

The strength of the impression is likewise increased by the elasticity of the sides of the bony canal, which receiving the first impulses of the air reverberate them on the auditory nerve.

The auditory nerves are distributed, one to the ear, the other to the eye, tongue, and parts adjoining. By the distribution thereof to different parts, an admirable consent is established between them. Hence it is, that most animals hearing a strange sound, erect their ears to catch it, open their eyes, and are ready with their mouth to shriek or call for help. A farther use of this nervous communication between the ear and the mouth is, that the voice may correspond with the hearing, and be a kind of echo thereof: and that what is heard with one of these nerves, may readily be expressed by the help of the other.

And now what less than an infinitely wise God could contrive so fine an organ, and such a medium, so susceptible of every impression, that the sense of hearing hath occasion for, to empower all animals to express their meaning to each other with endless variety? Yea, what less could form such an economy as that of music is? So that the medium conveys the melodious vibration of every animal voice or well-tuned instrument, and the ear receives them, to allay the perturbations, and calm and cheer the heart of man!

Though the ear be the ordinary organ of hearing, yet it is not the only one. We may hear by the teeth. For if one end of a knife be applied to a spinnet, and the other held between the teeth, the music will be distinctly heard, though the ears be ever so closely stopped. Yet this is not properly by the teeth, but by the auditory nerve which passes from the drum to the palate.

In those who are born deaf, the eyes may in some measure serve in the place of ears. Some can understand what is said by nicely observing the lips and tongue of the speaker; and may even accustom themselves to use their own, till they learn a kind of speech.

The education of the deaf and dumb has now become a regular science. Those persons admit of division into two classes: those who are dumb merely on account of being deaf, whose only imperfection is in the ears, and whose organs of voice and capacity of understanding are perfect; and the deaf mute, or those who are incapable of being in any way impressed with sensations of sound, and whose organs of speech are also unfit for the production of sounds. This species of education is highly important, as being a charity of the best kind to persons who are more gloomy than those who are deprived of sight; but we have not room to enter on the details.

26. The nostrils are not made of flesh or bone, but of cartilage, the better to be kept open, and, as

occasion requires, to be dilated or contracted, for which purpose they are furnished with proper and curious muscles. The tubes therein growing narrower and narrower, lead into several little cells and winding cavities, covered with a soft coat, and provided with arteries, veins, glands, and filaments of the olfactory nerves. This, therefore, is without all doubt the proper organ of smelling.

And forasmuch as it is by breathing that the odorant particles are drawn in, the laminæ with which the upper part of the nose is barricaded serve two excellent purposes, partly to prevent any thing hurtful from entering the breathing passages in our sleep (for which end likewise the hairs placed at the entrance of the nostrils serve), and partly to receive the divarications of the olfactory nerves, which are here thick spread, and by this means meet the smells entering with the breath.

Each of the cartilaginous laminæ is divided into many others, folded into a spiral line. The os cribrosum is made up of the extremities of these, the holes therein being the intervals between them. They are designed to uphold the inner tunic of the nose, which is folded round about together with these laminæ, that by its great expansion it may receive a greater number of the odorant particles. For the same reason, it is furnished with many small glands, which open into it, and moisten it with a slimy exudation, fitted to entangle and detain the subtle effluvia that touch it. And not only the number, but also the length of these laminæ, is of great use for the strength of smelling. For this purpose, most beasts, which either hunt, or distinguish their food by smell, have not their nose in the middle of their face, like man, but prolonged to the very end.

27. The tongue has for its basis that forked bone called the os hyoides. It consists of various muscles interwoven together, that it may be fit for various kinds of motion. To these are added very many small branches of nerves, which pass through the middle of it to the outside, and, being gathered into little bundles, constitute those papillæ which make its surface rough and uneven. Besides these, there appear also on the surface of the tongue certain pointed fibres, not unlike the ends of birds' claws, inclining towards the basis of it, with which are interspersed innumerable salival glands; and all these are in their several ways subservient to the sense of tasting.

That the tongue is an important member cannot be doubted, inasmuch as it bears a part in many operations. It assists in swallowing, in tasting, and in the voice. But it is not the only member used in any of these. The breath through the nostrils appears to have as much to do in tasting as the tongue; for if the nostrils are held close when drinking, one is unable to tell whether the liquid taken into the mouth is wine or water. It will be afterwards shown, that in the voice the tongue is only an assistant; and there are recorded instances of persons who have been able to speak after the tongue had been destroyed by disease. Man is almost the only animal that uses the tongue much in the modulation of sounds; and men who have not the use of the tongue, utter many sounds like those of animals. Thus the letter *r*, sounded without using the tongue, resembles the snarling growl of a beast of prey.

The human teeth are, in the full grown individual, thirty-two in number—sixteen in each jaw. They are distinguished into three kinds. The first four, in front of each jaw, are incisors, or cutting teeth; one on each side of these, four in all, are cuspidati (two-pointed), dog-teeth, or eye-teeth; and the teeth on each side of these last are called molares, or grinders. The last, or backward teeth in each jaw, are called dentes sapientiæ, or wisdom teeth, because they do not make their appearance till the parties come to full maturity.

The ossification of the jaws in the fœtus begins about the second month after conception; and though there are instances of the fœtus being born with teeth, they are rare. The time of cutting the teeth is usually from the seventh to the seventeenth month. It is commonly preceded by an itching of the gums, and by convulsions, fevers, and looseness; most of which symptoms happen to birds also, upon moulting, or casting their feathers. The rudiment of the teeth is a mucous matter, like the white of an egg, contained in the cells of the jaw-bone, which grows harder and bigger till it breaks through the gum. The middle incisors are, in most instances, the first cut; and by the third year the child has usually got twenty teeth, all of which, however, are temporary; and these are shed, and the permanent teeth chiefly make their complete appearance by the twelfth year; few teeth but the wisdom teeth are later.

That part of the tooth which stands out of the gum is covered with a peculiar substance called enamel. It is composed of an immense number of little tubes, which grow on the bone by their roots. If any part of this be broken off, so that the bone is left bare, it grows carious, there being no bone which will bear the air.

We may farther observe, 1. That the teeth only of all the bones grow in length during a man's whole life; which is providentially designed to repair the waste that is continually made by attrition. 2. That the teeth are the only bones which are not covered with that exquisitely sensible membrane, the periosteum. 3. That they are harder and firmer than any other bone, that they may be more durable and fit to chew the most solid aliments. 4. That for their nourishment, there is a cavity contrived in each side of the jawbone, in which are lodged an artery, a vein, and a nerve, which, through smaller cavities, send their twigs to every tooth. 5. That as infants are designed to live on milk for some months, they are so long without any teeth; whereas animals that need them have them sooner, and some are even born with them. 6. The different shape of the teeth is remarkable: the fore teeth are formed broad, and with a thin and sharp edge, like chisels, to cut off a morsel from any solid food; the next, one on each side, are stronger, deeper rooted, and more pointed, to tear tougher aliments; the rest are made flat and broad at top, and withal somewhat uneven, that thereby they may the better retain, grind, and mix the aliment. 7. Because biting and chewing require much strength, partly in the teeth themselves, partly in the instruments that move the lower jaw, which alone is moveable, nature has given it strong muscles, which make it bear forcibly against the upper jaw; and has not only fixed each tooth in a distinct cavity, as in a close, strong, and deep socket, but has given hold-fast to the several sorts of teeth, suitable to the stress that is to be laid upon them. So whereas the cutters and eye-teeth have only one root, the grinders, designed for harder work, have three—in the upper jaw often four because they are pendulous, and the substance of the jaw somewhat softer. 8. The situation of the teeth is most convenient: the grinders are behind, near the centre of motion, because chewing requires a considerable force; the cutters before, ready for their easier but more rapid work.

28. The palate is of a bony substance, a little concave, and clothed with a thick membrane, which has the same kind of servous papillæ and small glands that are seen in the surface of the tongue; and hence it is qualified to assist the taste as well as the speech.

The organs of speech, or those which are subservient to that modification of the air in breathing by which sounds are produced, are much more complicated in man than in most animals. The lips, the teeth, the tongue, the general cavity of the mouth, the soft parts which are situated in the posterior part of the mouth, and even the nostrils, are all of use in the formation of words, or the most important faculty of speech. These, however, are only modifying organs, just as the sound of a flute or clarionet is differently modified by stopping the holes; for the real and original voice is in that organ which answers to the reed of the clarionet, or to the lip and hole of the flute. This is called the larynx; it is situated at the upper or mouth extremity of the windpipe or trachea, afterwards to be described, and it is of a structure which is not easily explained in words, although the two sides of it are perfectly symmetrical, which means that the one is the exact counterpart of the other. The opening of the larynx is called the glottis. It is in the form of a slit supported by a cartilaginous ring, called the cricoid, which forms as it were the substance or frame work of this wonderful musical instrument. Above this is the thyroid cartilage, which protects the cavity of the larynx like a shield forming in man that protuberance on the windpipe which is called pomum Adami, or Adam's apple. To these and to numerous other cartilages are attached the valves of membrane which partially shut the glottis, according to the quantity of breath which passes in producing different sounds; and it is remarkable that there are no fewer than twenty-six pairs of muscles, or fifty-two in all, which give motion to the different organs employed in the modulation of speech. Of these, eight pairs, or sixteen in all, are connected directly with the larynx; fifteen pairs are connected with the larynx and the bone of the tongue, and three pairs are connected with the bone of the tongue and the lower or moveable jaw. Calculations have been made of the extreme flexibility of this organ, which can shift its aperture, without the owner knowing how, to shades of difference compared with which the breadth of a hair is great. But, as we shall afterwards see, the hand in the dark, unassisted by the eye, can divide space to less than the two thousandth part of an inch; and therefore the mere changes of its aperture are not the wonderful part of this singular organisation. The grand marvel is that every individual of the human race has a different tone of voice from every other, so that he is as readily known to the ear as to the eye; and that while this general and personal tone is preserved, every shade of feeling, and every kind and degree of passion to which the mind of man is subject, can be readily expressed by the voice. There is no doubt that this requires the consent and cooperation of the whole vocal structure; and thus it is a matter far above our explanation, and would of itself be an unanswerable proof of the infinite wisdom of man's Creator.

In most quadrupeds, too, the glottis is the principal organ of the voice. So it is in cats, sheep, and several others. But many have something more than a glottis, as horses, asses, mules, and swine. Some of these have only a tendinous membrane, which concurs in forming the voice. Others have several membranes: others a kind of bag, which in some is membranous, and in others bony. Others have both membranes and bags. Others, lastly, have in their larynx a kind of cavity or drum, which assists them in uttering very strong and long continued notes.

All sounds are produced by a swift succession of vibrations from the particles of sonorous bodies which agitate the air. But the vibrations of the lips of the glottis would not suffice to produce the neighing of a horse. This begins by more or less acute interrupted tones, accompanied by quaverings, and ends by tones more or less grave, which is performed by jerks. This second part is done by the lips of the glottis: the other chiefly by a small elastic membrane. This is tendinous, very thin, of a triangular figure, and lies flat on each extremity of the lips of the glottis. As it adheres but loosely to these, it can easily flutter up and down; and it is the play of the membrane up and down, which produces the acute sounds of neighing. These are more or less acute, as the membrane is more or less thin, and its adhesion more or less slack. The grave sounds that conclude the neighing, are excited by the flutterings of the thick strings which form the lips of the glottis.

The hoarse sound of the ass's voice is not so much produced by the lips of the glottis, as by a tendinous part which adheres loosely to the aperture of a kind of drum, situate under the extremity of the lips of the glottis: above which are also found two large and thick bags, one on the right, the other on the left. Each of these has a roundish aperture, cut much like the stopple of an organ.

Such are the organs which form this amazing sound. A kind of drum is the principal: and the two bags above the lips of the glottis, are the main auxiliaries; while those lips, as plain experiment show, contribute very little thereto. The mule's voice much resembles that of his sire, and is formed by much the same organs: the drum of so singular a composition being found in mules also.

There is another animal which affords us a particular disposition of the vocal organs. This is the hog, whose shrill cries are more insupportable than his usual grunting. Yet neither are these excited by the lips of the glottis, but by the fluttering of two large membranous bags, situated on each side above the lips of the glottis. What is most remarkable is, that each lip is cloven almost its whole length. By this cleft, each lip has a communication with the bag belonging to it; and the motions of these bags produce most of the sounds peculiar to this animal.

Though the voice of birds bears a nearer resemblance to ours than that of quadrupeds, yet their organs have far less resemblance to ours, and contain a greater number of singularities. They, like us, have a glottis at the top of the trachea; but they have another at the bottom of it, which much contributes both to the strengthening and modifying of their voice. These have different membranes, more or less fine, more or less bent, and in a variety of positions. In some birds, as in geese, there are four of these, figured and disposed like the reeds in hautboys.

With regard to the human voice, an ingenious man observes, "Sitting in company I chanced to take notice, that in ordinary discourse, all that is spoke, is spoken in perfect notes; and that some of the company used eighths, some fifths, and others thirds. I observed likewise of him whose speech was the most pleasing, that all the tones he used consisted either of concords or of such discords as made up harmony."

Cutting the trachea was long reputed mortal, but it is now usual to open it in dangerous quinseys. This physcians were at first encouraged to do, from the case of a Cornish gentleman, who had his windpipe quite cut through, and yet was cured and lived several years after.

The trachea, or windpipe, is wonderful in its conformation. Because continual respiration is necessary, it is made with annular cartilages, to keep it constantly open, that its sides may not fall together; and lest when we swallow, any particle of food should fall in, which might cause convulsions, or even death, it has a strong shutter or lid, called the epiglottis, which, whenever we eat or drink, falls down of itself, and covers it close, so that no crumb or drop can enter. It is for the more convenient bending of our necks that the windpipe is not made of one entire continued cartilage, but of many circular ones.

What is farther remarkable in these cartilages is, that all the way where they are contiguous to the gullet, they are membranous, to give an easy passage to the food, but after that there are some completely round, and some triangular. Another thing observable is, that in the windpipe the cartilages run parallel to each other; but in the lungs the lower parts of the superior cartilages receive the upper parts of the inferior, hereby enabling them to contract themselves in expiration, and to dilate in inspiration.

The human hair originates from the cellular substance below the skin where the root of each hair forms a sort of bulb; and each hair is enveloped in a transparent sheath, which in vigorous hairs is rounded. It does not appear that this covering of the hair is derived from the epidermis, though it resembles that tissue in substance. The central or medullary part of the hair is that to which it owes its colour; and though the hair itself has little sensibility, and may be divided without any painful sensation, it is remarkable that it is more susceptible to the effects of passion or strong feeling, than almost any other part of the body. Very many instances have been recorded of entire loss of colour in the hair, produced in very short periods of time, sometimes in a single night, by the influence of grief or terror. As the external covering of the hair is perfectly transparent, we can account for this change of colour, only by a change, or direction in some other channel, of the colouring fluid which it contains when in a healthy state. This is farther proved by the fact of hairs whitened in this manner losing their cylindric shape, and becoming angular or flattened. In some cases the quantity of this fluid is unnaturally great, and when it is so, it appears to be improperly concocted, and to differ little from the general mass of the blood. This is shown in the disease called plica Polonica, (from its being understood to be more frequent in Poland than in any other country,) in which the hair bleeds upon being cut and so much of this fluid exudes through the tubes of the different hairs, that the hair is soldered into one mass. Hair grows in length apparently from its roots only; and the growth seems to be favoured by shortening it at the other extremity. In some instances it is recovered in the human subject after being partially or even wholly lost; but in the baldness which takes place in old age, there appears to be no means of reproduction; and all the nostrums which are advertised for this purpose are mere impositions.

Dyes are sometimes used for changing the colour of the hair, the principal ingredient of which is usually nitrate of silver, and this blackens the hair much in the same way as it blackens the skin—the surface merely, without affecting the true seat of colour. A very ludicrous effect is sometimes produced by an overdose of this dye, in which case the hair often assumes all the colours of the rainbow, as bright as they appear in the cloud. As the hair comes through the integuments from the cellular tissue below in a complete sheath, it does not appear that its outer coat is derived immediately from the cuticle, or its medullary part from the mucous web, on which the complexion of the skin depends. There seems, however, to be some connexion between these two parts at their origin; for in albinos, who want the colouring matter in the mucous web, the hairs are perfectly white. They are as healthy and as vigorous in their growth as hairs of any other colour, which leads us to conclude that the colouring matter is an accessory part of the hair, and not an essential. It is understood to reside in a peculiar oil in the medullary part; but whether there is a similar oil in the mucous web has not been ascertained. The varieties of shade in the hair of the mixed nations of Europe, are almost as great as the tints of complexion, or even as the expressions of faces.

Though hair feels no pain when compressed or divided, it is so far from being destitute of sense in the living body, that the skins of many animals accustomed to find their way in the dark, serve, through the medium of hairs, as guides to them on their way. Thus a horse will stop before running against a wall or bar on a dark night, when the rider has not the slightest idea of its existence; and the wiskers of all those animals which prey in the dark, not only warn them of obstacles against which they might injure themselves, but enable them to steer through sprays and bushes in comparative silence, and thus come upon their prey with more certainty. Hair when dry is also a non-conductor of heat and of electric action; and thus it preserves the bodies of those animals which are covered with it, from the disturbing influence of the most powerful and the most variable of all agents. The same may be said of feathers, and of the coverings of animals generally; and as these adapt themselves to different climates with the greatest nicety, the wisdom of design in this part of the animal economy is truly wonderful. Nor is it unworthy of remark, that the frizzled hair of the negro, who is exposed to the burning sun, is a defence against heat; while the long and lank hair of the northern nations resembles a thatch for throwing off the rain or snow. In civilised countries we can form no judgment of the human hair, because it is rarely in a natural state, or exposed to the natural contingencies of the weather.

The nails are of the nature and fabric of the cuticle, like which they are also insensible, and renewable, after being cut or falling off. They are placed upon the backs of the ends of the fingers and toes, which they support to make a due resistance in the apprehension of objects, having the nervous papillary bodies, that serve the organ of touch, placed under their lower surface. They arise with a square root, intermixed with the periosteum, a little before the last joints, from betwixt the outer and inner stratum of the skin, and passing on soft, go out by a lunar cleft in the external plate of the skin, where the cuticle returns back, and enters into a close adhesion with the root of the nail, together with which it is extended as an outer covering. The hair and nails are mere protections, and not essential in the functions of life, is proved by the fact of their growing most during sickness, and continuing to grow after the body is dead. They are however affected by the living action; for when the stomach is disordered the nails become brittle and the hair loses its gloss.

29. We proceed to the middle cavity of the body. Herein the principal part is the heart, consisting

of a strong tendon, extended obliquely from the basis, or broader part, to the cone, into which the fleshy fibres are inserted, in an elegant series, with a spiral bending, one half opposite to, and crossing, the other; by which means the grand muscle is admirably fitted, both to receive and to propel the blood. It has two great cavities, usually termed the ventricles of the heart. They are divided from each other by an intermediate part, called the septum, constituted by the same fibres, which is convex on the side next the right ventricle, and concave on the other. The vena cava brings the blood to the right ventricle, and, two inches from its insertion, divides into the upper and lower. The former brings the blood into it from the upper, the latter from the lower parts of the body. The pulmonary artery carries the blood from the ventricle into the lungs, which the pulmonary vein brings from thence into the left ventricle. At the upper side of these veins, there is added to each ventricle a kind of purse called the auricle, which is a hollow muscle of the same structure with the heart, in order to stay the blood, that it pour not too violently into the ventricle. Before the orifices of the veins of the heart there are triangular valves, and semilunar in the orifices of the arteries, to hinder the reflux of the blood, from the auricles into the veins, from the ventricles to the auricles, and from the arteries into the ventricles. In a healthy person, the heart contracts nearly five thousand times in an hour.

30. The heart is covered with a fine membrane; and near the base of it, on the outside, there is a little fat, probably designed to facilitate its motion. It is placed near the middle of the breast; only its cone inclines a little to the left. It hangs by its

base on veins and arteries, communicating with all parts of the body. The other part of it is loose in the pericardium, that it may be the more commodiously constringed and dilated. The pericardium is a kind of membrane, that, like a kind of purse, loosely incloses the heart. The shape of it is suited to that of the heart, and it contains a thin, saltish, reddish humour, exuding from the arteries.

In man, and all other warm-blooded animals, the action of the heart is double: the blood which returns from the body, and receives the nourishment in its course, is returned into the systematic auricle, and collects there, while the pulmonic ventricle is collapsed in its pulsation. Immediately on the expansion of the pulmonic ventricle, the blood in the systematic auricle flows to it; and as the passage which opens from the auricle shuts from the ventricle, the next contraction drives the blood along the pulmonary arteries towards the lungs; meanwhile that portion of the blood which has been to the lungs, and has there received the purifying influence afterwards to be described, returns to the pulmonic auricle of the heart; and the moment that the systematic ventricle expands, the renovated blood from the pulmonic auricle enters that ventricle and is conveyed over the whole body; and when it has done its office there in repairing and refreshing the different organs, the remainder is brought back to begin the circulation anew.

Thus there is a double pulsation of the heart and a double circulation in those warm-blooded animals; yet the two systems are not distinct from one another, but form part of one compound revolution. The new substance of the blood, which is crude and unfit for the particular purposes of so delicately fine an engine as the body, is taken into the mass of systematic blood, as that blood is returning to the heart loaded with those impurities which it has removed from the system, and deprived of those parts which it has given out to the several organs. There is a beautiful economy and simplification in this. The exhausted blood, and the crude materials, go to the preparing lungs together, which not only saves an apparatus and an operation, but, we have reason to believe, makes the blood better. Analogies are often curious in nature, and we know that better glass or pottery is produced when broken glass or pounded potsherds mix with the crude materials; and that too great an addition of crude matter at once to the blood injures it and deranges the system, is proved by the case of every inordinate feeder, whether of the human race or of any other. The circulation continues to the lungs and returns from the lungs through the other portion of the heart; so that in passing through that organ, the two streams cross each other, though they do not mingle; and as the pulmonic and systematic sides of the heart have their muscles quite distinct from each other, it is not necessary that the two pulsations of the heart should be performed together. The real passage is to the lungs from the system, and to the system from the lungs; and as each of these is to a different part of the body, they are liable to be differently affected, —as the lungs may be diseased while the system is sound, or the system may be diseased while the lungs are sound; and the whole body is so admirably contrived that, within considerable limits, either of those systems may become diseased and recover again without material injury to the other.

31. The principal organs of respiration, without which the pulse of the heart would beat in vain, are the lungs, which consist of two parts, the right and left lobe. Each of these is divided into two other lobes; one of these frequently into three, sometimes into four, by fissures, sometimes deeper, sometimes shallower, running from the interior margin towards the back part. The lungs are divided into cells, which are no other than expansions of the small branches of the trachea or windpipe. And there is an easy passage from one branch into many cells, and again into it from them all. The upper part of the trachea opens into the mouth; the lower, divided into two branches, shoots out into various ramifications, which are termed bronchiæ. And these little canals running on, constitute the lungs, whose cells are wonderfully connected together, and intermixed with numberless branches of veins and arteries.

The lungs are pink in young persons, greyish in middle life, and blackish in old age. They are very soft and elastic to the touch, and by much the lightest part of the whole body. In their natural state they swim in water; but when completely exhausted of air they sink, and hence it is known by trying the lungs in water whether an infant that is found dead, has or has not been born alive, as if it has been born alive the lungs swim, otherwise they do not. The lungs in substance consist of the proper walls of the cells, which are all connected with each other and with the bronchial continuations of the windpipe, but they communicate with no other part, and have no opening through which air can pass except the windpipe. These proper cells of the lungs are embedded in common cellular tissue, and enveloped in a fine transparent membrane, which, like the membrane enveloping all the organs in the thorax, is a continuation of the pleura. All the cellular membrane is thickly ramified with very minute blood vessels, consisting of arteries and veins, and thin capillary connections. Those blood vessels are of two kinds,—the proper vessels, by which a portion of the systematic blood is sent for the nourishment of the lungs, and brought back after it has performed its office, in the same manner as from the other parts of the body; and the pulmonary vessels, which carry the general mass of the blood to the lungs, for the purposes of purification, and returning back again to the systematic ventricle of the heart, through the pulmonic auricle, after it has been renewed and become fit for the functions of life. Thus there is this remarkable difference between the pulmonic and the systematic systems of vessels, that the pulmonic arteries carry venous blood from the heart, and the pulmonic veins bring arterial blood to the heart; while the systematic arteries carry arterial blood to all parts of the body, and the systematic veins bring back venous blood. Hence it appears that the only function which the heart performs in the circulation of the living fluid, is the mere putting it in motion, without either improving or deteriorating its quality; and that the lungs are the essential organs in altering the condition of the blood.

They are the organs of respiration; but before we can understand how they perform their office, some other parts must be noticed. The principal of these are the intercostal muscles, or muscles between the ribs, the diaphragm, and the abdominal muscles, or muscles of the belly; which are the chief instruments by which the lungs are worked, as there is no muscle in the lungs themselves. Of those parts the diaphragm is the most important. It is situated between the thorax and the abdomen, like a sort of curtain; and its muscles are united to the cartilaginous extremity of the breast bone, and to the cartilages of various ribs. The under part of it is also united to the vetrebræ of the loins; and when the lungs are in a state of repose, that is, when breath is neither drawn in nor given out, the diaphragm is hollow on the under side, and bent upwards to the cavity of the thorax. When breath is drawn in, the diaphragm flattens downwards, which not only enlarges it lengthways, but allows the intercostal muscles to extend it on the sides. This being done the pressure of the air immediately fills all the cells of the lungs with that fluid; and this is called the inspiration of the breath.

It is now that one of the mysteries of our wonderful frame comes into operation. The air which is received into the lungs consists of two distinct ingredients, nitrogen more than three fourths, and oxygen less than one fourth. This compound air remains a very short time in the lungs; and there is no passage from the cells to even the blood vessels which will allow air to pass; and yet during this very short continuance the air is completely changed. It does not, as was once supposed, give out its oxygen to the blood; but that oxygen is mixed with as much carbon, or charcoal in a state of air, as converts the whole oxygen of the inspired air into carbonic acid gas, which gas in the lungs is injurious in any quantity, and a deadly poison when unmixed. As soon as this change has been made both on the air and the blood (though how it is made is a mystery), the contaminated air, no longer fit for the purposes of life, becomes painful to the lungs; the diaphragm relaxes, the chest contracts, the air which has done its office is expelled, and, all is ready for a second inspiration. There is something altogether beyond our knowledge in this simple yet beautiful operation, an operation which in some form or other is common to every living creature; but in the portion which we can understand, namely, the effects which it produces, it is passing wonder. For here, when the tide of the blood has performed its function, and is no longer fit for the purposes of life, we find that the product left behind, which is the contaminating part, is the same which is left behind in a common fire, when every combustible has been destroyed, namely, charcoal or ashes; and if we take this product and pour it like water on a burning candle, that candle is more effectually and silently extinguished than if we poured water on it.

The whole thorax is covered on the inside with a firm, white membrane, called the pleura. It is double throughout, consisting of two folds, the innermost whereof has a smooth surface, that it may not hurt the tender substance of the lungs, the surface of the outer is rough and uneven. From the pleura rises the mediastinum, which is a double membrane, that divides the lungs and the cavity of the thorax lengthwise into two parts.

32. On the slightest observation, we cannot but acknowledge the consummate wisdom wherewith the external parts of the middle cavity are formed, for beauty, as well as for the defence of the internal. This is commodiously connected with the

head by the neck. The breast, or fore part of the thorax, which begins at the throat and ends at the sternum, or breast-bone, is an admirable guard to the noble parts. To the same end serve the shoulder blades and the back bone, as well as to support the whole fabric.

The breast consists of numberless oval glands, intermixed with globular vessels of fat. Their ducts as they approach the nipple, unite together, till they form eight or more small pipes, communicating with each other by cross canals, which are of great use, when some of them happen to be obstructed. These tubes are in some parts narrower, in some wider, so as to form cells, which hinder the efflux of the milk. The paps consist chiefly of the concurrence of these tubes, but with a glandulous substance intermixed. There are likewise joined herewith abundance of fibres, from the external teguments of the breast, by means of which the tubes are constringed, and the motion of the milk is modified.

It is highly probable that, during the whole period of fruitfulness in females, the breasts secrete the catamenia, which is a fluid *sui generis*, and not blood. There are also instances of preternatural secretions of real milk in old women, and even in men.

13. In the lower cavity first occurs the stomach, with the œsophagus or gullet, which reaches to it from the mouth. The right orifice, called the pylorus, transmits the digested food to the intestines. It is narrower than the other, as being designed to transmit nothing until it is reduced to a kind of liquid. And it goes by a long and oblique

descent into the duodenum, that the chyle may not pass out either too swiftly or too slowly.

The upper opening of the stomach is compressed in such a manner by the lower muscles of the diaphragm, in every inspiration, as to confine the food within the stomach, and direct it in every respiration towards the pylorus. By this means this orifice of the stomach is so closely shut, as to confine even wind or vapours within the capacity of an healthy stomach, whence they never escape but by a morbid affection.

The fabric of the stomach answers to that of the œsophagus, of which it is an expansion. 1. The outmost coat is, from the peritoneum, of considerable strength, so as to limit the extension of the rest, and afford a support to the subjacent muscular fibres. 2. The cellular coat lies immediately under the former, whence the outer and muscular tunic closely cohere together ; in this substance the larger branches of the vessels are distributed. Next in order appears, 3. the muscular coat. Here, the longitudinal fibres of the œsophagus, coming to the stomach, are detached one from another in all directions.

Immediately under the muscular fibres, follows, 4. another cellular stratum, larger than the outermost, softer, more easily inflatable, and consisting of larger vesicles than what we usually observe, even in the intestines. Within this cellular substance are spread the small vessels, which, coming from the larger branches of the stomach, enter through its muscular coat, and spread internally after the manner of a plexus. Under this lies, 5. the nervous coat, which is thick, white, and firm, and makes up the true substance of the stomach itself, and this is again lined internally with a third cellular stratum, whose vascular network is much more minute than that of the former, whence it is derived. Immediately within this lies, 6. the villous or velvet-like coat, that lines the cavity of the stomach itself, continuous with the external cuticle, like which it is renewable, but of a soft mucous texture, and extended into a very short pile, like that of the tongue, only less conspicuous, and folded into large plates.

34. The intestines are a continuation of the alimentary tube from the pylorus, wound together in various wreaths, yet without confusion, and, to keep them in their situation, fastened together by the mesentery, a strong membrane, which fastens them also to the back. The intestinal duct is really but one; but because the parts of it differ in figure and use, the upper part of it, divided into the duodenum, jejunum, and ileon, is termed the small guts; the lower part, divided into the cæcum, colon, and rectum, is called the great guts. All these are full of turnings and windings, especially the small, that the more subtle part of the chyle, both through the length and narrowness of the passage, and the agitation of the intestines, may enter the lacteal veins, and pass from thence into the receptacle of the chyle.

When the intestines are separated from the mesentery, they are usually six times as long as the man. They have all a kind of vermicular motion, called the peristaltic motion, from the stomach downwards; and are lubricated with much fat, especially the great ones, whose surface being more uneven, and their contents less fluid, they need somewhat more to make them slide easily.

Likewise from the exhaling arteries distils a thin watery liquor into the cavity of the intestines, not at all acid, but like the juice of the stomach; the quantity of which liquor may be computed from the large extent of all the excretory orifices, and from the section of the secretory artery, a larger than which we see nowhere in the body.

The duodenum, (so called because it is usually ten or twelve inches long,) receives the gall and pancreatic juice, which are here mixed with the chyle. The jejunum is so termed, because it is generally more empty than the rest. This may be occasioned partly by its capacity, which gives a free passage to its contents; partly to its irritation through the bile, which falls in a little above it. It takes up almost the whole unbilical region, and is usually twelve or thirteen hands long. The ileon, situate below the navel, fills the ilia with its numerous convolutions. It is much the longest of all the intestines, generally one and twenty hands long. In both this and the jejunum the inner coat is much wrinkled and lies in loose folds. They are formed (as the folds in the stomach) only by the inner coat being larger than the outer.

The first of the great guts, called the cæcum, is laterally inserted at the upper end of the colon. It is not perforated at the other end, but hangs to it like the finger of a glove, and is three or four inches long. In new-born children and in beasts it is found full of excrements, but in adults it frequently hangs like a worm. In a fœtus it is doubtless a receptacle of the fæces during the time it does not discharge by stool. And may it not occasionally serve the same end in adults? Perhaps in those animals wherein it is very large, it may likewise serve as a kind of second stomach. But it is not absolutely necessary: the cæcum of a dog has been cut out without any perceivable prejudice.

The colon is the largest of the great guts. It runs in various circumvolutions from the cæcum to the rectum. It has many cavities formed by two ligaments running on each side of it, opposite to each other the whole length, and, as it were, guiding it at certain distances. The rectum, which reaches from the os sacrum to the anus, is usually about a hand and a half long.

35. The lacteal vessels, which are of a whitish colour, are in all the intestines small and great, and receive the chyle by imperceptible passages throughout the whole canal; and for this end the food remains so long in the intestines, and is carried through various windings, that whatsoever of nourishment it contains may be expressed before it leaves the body.

36. The intestines are covered with the omentum or caul, which is contained within the peritoneum, a very thin, soft, double membrane, and wholly consisting of little bags of fat. Its use is to keep the intestines warm; to promote their peristaltic motion by lubricating them with its oily substance; by following them in their doublings and windings, to serve them as a bolster to slide upon; and by filling up their hollows, to prevent their being too much distended by flatulences, yet giving way to them when filled with aliments.

Under the stomach, behind, lies the pancreas (extended towards the spleen), which transmits to the intestines a liquor of the nature of saliva, helping to dissolve the food.

37. Under the diaphragm, on the right side, lies the liver, whence it extends over the right part of the stomach, below the sternum, towards the left, growing gradually smaller, that it may not hinder the distension of the stomach. It consists partly of gall ducts, partly of fine ramifications of the vena porta. The blood contained in these deposits oily particles in the ducts, and then returns, chiefly through the vena cava, to the heart. It is thus the bile is secreted, for which purpose the gall-bladder also is designed. This both receives and retains the bile, by which delay the power of it is greatly heightened. Part of the bile is conveyed to the intestines by the hepatic duct, which pours it into the ductus choledochus. Part goes first into the gall-bladder, thence into the ductus choledochus, and then into the duodenum.

The principal use of the bile is so absterge and stimulate the intestines; to assimilate crude things to things concocted; to bruise and blunt sharp and saline particles, to divide those that are coagulated; to excite appetite; to open the passages for the chyle; and, where need is, act the part of a ferment.

38. The spleen is an elegant net-work of numberless vessels, enclosed in a double membrane. It is placed on the left side, between the short ribs and the stomach. Some suppose it to secrete a peculiar juice, which passes with the blood through the vena porta.

39. On the muscles of the loins on each side lie the kidneys, to separate from the blood that part of the serum which is superfluous, and would be

hurtful were it retained in the system. This is carried by the ureters into the bladder, which is placed in the lowest part of the belly. What remains of the blood is conveyed to the heart by the veins and lymphatic vessels.

The bladder is composed of three coats:—the first is an extension of the peritoneum; the second consists of muscular fibres; the third is both glandulous and nervous, and full of wrinkles, that it may be capable of contraction and dilatation. Its glands separate a slimy matter, which defends the bladder from the acrimony of the urine. The involuntary emission of this is prevented by a small muscle which goes round the neck of the bladder.

40. We proceed to the limbs. The limbs of the human body are the arms and legs, with their terminations, the hands and feet; and so curiously are they formed, and so countless is the number of purposes that they are capable of answering, that they alone, if duly contemplated, are sufficient to prove to any one's conviction the two following truths:—First, that He who made man is infinite in power, wisdom, and goodness; secondly, that man is ordained for a higher and nobler purpose than any other animal with which we are acquainted. Each arm, with its hand, is composed of thirty-two bones, of which there are eight in the wrist, five in the palm of the hand, twelve in the fingers, and two in the thumb. The leg, with its foot, contains thirty bones, of which there are seven in the ankle and heel, five in the body of the foot, and fourteen in the toes; so that there is one bone more in the wrist than in the corre-

sponding part of the foot, and one bone more in the junction of the arm to the body than in the junction of the leg. The number of separate muscles belonging to the whole of each of these four members is the same, namely, forty to each; and as they can perform motions consisting of any combination of positions of themselves or their bones, it would be as vain to attempt counting the motions of the foot, and more especially of the hand, as it would be to count the sand on the sea-shore, or the drops in the ocean. Truly this part of the human frame is "wonderfully made." But it is not less wonderful that this, the most perfect apparatus with which any animal is provided, is not adapted to any one particular purpose. Some other animals, as will be afterwards seen, have hands, but they are merely grasping hands, by means of which the animals can take hold of and suspend themselves from the branches of trees. The hand of man can grasp, but not in the same fashion. It is a working hand, and points out that man is to do whatever reason and justice teach him, and to do it diligently. So also the human foot is not adapted for travelling upon any one kind of surface as is the case with the foot of every other animal; and therefore the very structure of the foot shows man that he has another governor for his motions besides those instincts which the other animals obey,—that this body is thus broadly distinguished from theirs in being a fit abode for the immortal spirit.

41. Thus far we have spoken concerning the solid parts of the human body, or we have made reference to the fluids only so far as to point out

the uses of some of the more important organs. We shall now devote a very few sentences to the consideration of the more important fluids.

Among these it was at one time usual to include the "animal spirits," but nobody who used that name could tell what was meant by it, other than that it was a sort of general and shadowy expression for life itself, in the same manner as when a man is very lively we say he is in "high spirits," or has "a great flow of animal spirits;" and when he is heavy and melancholy, we say that he is in "low spirits," or that "his animal spirits are dull and languid." It is not perhaps very easy to avoid the use of such expressions in common speech; but we require to use them with great caution, and even to avoid their use altogether, when we come to speak philosophically of the nature of things. From all the senses in which they are used, it is evident that the words "animal spirits" are nothing but a general expression for the performance of those functions of the body which we cannot trace to motion or change in anything material; so that the high spirits mean a healthy state of the body and a happy temper of the mind, and the low spirits mean the reverse; and having said this, we can add nothing which would not be in itself erroneous, and also lead to farther error.

The fluids in the body, which are too numerous, and some of them too well known, or of too little interest for being detailed in this compendium, may be divided into three classes:—First, fluids of assimilation, or those which go from without to nourish the system; secondly, fluids of circulation, or those which are carried to different parts of the body, either for the direct supply of the organs thereof, or for furnishing materials out of which new fluids are elaborated; and thirdly, fluids of secretion, or those which are separated from the circulating fluids by glands, by secreting surfaces, or by other organs adapted for the purpose. The last may perhaps admit of subdivision into secreted fluids, which perform some office before they are discharged from the body; and excreted fluids, which are discharged without apparently performing any office. The perspirable matter of the skin, and the fluid collected in and discharged from the bladder, are among the chief of these last.

The principal fluid of assimilation is the chyle, which begins to be prepared by mastication in the mouth, is farther advanced by digestion in the stomach, and there changed into a peculiar pulpy mass, called chyme. This chyme passes into the intestines, where it mixes with the fluids discharged from the liver and pancreas; and in its progress through the intestines it is taken up by the mouths of the lacteals, and carried by them through the glands of the mesentery to the thoracic duct, which carries it into the subclavian vein, and so into the circulation. In its progress, this fluid gradually changes from the consistency of the food to a milky state, which process is called assimilation; but it is doubtful whether this process is complete, that is, whether the nourishment becomes really a part of the body until it is actually mixed with the mass of blood, and has gone with that to the lungs, and back again to the systematic ventricle and arteries.

There is one point which is worthy of attention here, though it is one upon which it is very difficult if not impossible to get correct information; and that is, whether the carbon which is given out in the lungs by breathing, comes from the returned blood in the veins, or from the chyle; but we shall probably have to revert to this in the next chapter, when we speak of the natural state of the human body.

42. The chief of all the fluids in our body, and the fountain of life, is the blood. It consists of a watery serum, fibrous particles, and red globules, which last are scarcely a twelfth part of it. It is generated thus. The meat and drink being digested into chyle, pass from the intestines, through the lacteal vessels and the thoracic duct, into the left subclavian vein, and thence into the vena cava, where it mixes with the blood, and then circulates with it, till it is wholly assimilated.

Blood fresh drawn appears to the naked eye uniform and homogeneous; but when cold, it separates into two parts, the one red and fibrous, which clots together, the other thin and transparent, called the serum, in which the former swims. The serum is in bulk three-fourths of the blood, in weight fifteen seventeenths.

The blood in the large arteries is of a bright pure red colour, and that in the veins of a brownish red; but whether this difference arises more from what the blood has parted with or what it has taken up during the circulation, is a point not easily ascertained. Blood contains a number of ingredients, such as water, a peculiar matter called fibrin, —which some suppose, not without reason, to be animal texture in a rudimental state,—albumen, or substance resembling the white of egg, and various salts of ammonia, soda, lime, and iron, together with some soda in a pure state. The red particles, on which the colour of the blood appears to depend, are very small, so much so that fifty millions of them would not make one solid inch. They are understood to differ in size in different animals, and also in the same animals when young and when full grown; but these points are very nice, and require to be treated with the greatest caution.

43. It was long a question among those who studied the human body, or the bodies of animals generally, in what manner these came by their natural heat; and even since the nature, or rather the action of heat came to be better understood than it was in more early times, there have been considerable differences of opinion on this subject. There are several causes why this should be the case: First, the subject is one of great difficulty, because it consists more in what we do not know, than in what we do know; and, secondly, the erroneous belief that fire, as a substance, was an element, that is a material element, of bodies and of the human body among the rest, had been so long and so generally believed that it was very difficult to be got rid of; and as, like the lingering remains of other errors, it continues in words after it has been disbelieved in reality by the better-informed, it still continues a stumbling-block to those whose knowledge is limited.

In all cases in nature where we cannot see a material organ or material substance employed in producing an effect, but must judge of even the immediate agent and cause from the effect itself, the best explanation we can get is the one that explains the greatest number of cases different in their circumstances, but as nearly as possible alike in their kind. Now, when we observe the human body, we find that its apparent heat in the whole, or in any one part, is always in proportion to the action of that part. Thus, in violent exercise of the whole body, the whole body gets warm; and in exercising any part violently, while the rest remains still, the part so exercised becomes warm, and the other parts do not. It is the same with those internal motions and actions by means of which the functions of life are carried on, or rather perhaps which are in themselves the functions of life. If an injury stops the circulation it is attended with throbbing and great heat; and if a diseased state of the whole body render the circulation more difficult, and the body in consequence labours in the performance of its functions, heat and fever are the result. Young persons are warmer in their temperature than persons in middle life, and these again are warmer than old persons. In all these cases, too, the pulse invariably beats quicker as the body becomes more sensibly hot, and slower in proportion as the body becomes more sensibly cold.

In other animals the facts correspond. Those which perform active motions have a warm temperature and a rapid circulation; and those which perform slow motions are cold, and have the pulse languid. In those animals which spend the winter in a state of hybernation or dormancy, the pulse sinks and the heat diminishes. In every case, in fact, in which we observe an increased heat, there has been an increased action; and in every case where we observe a diminished heat, there has been a diminished action. This holds not only in the animal world, but in the whole material world, in so far as we can observe it; and therefore we have as complete evidence of the source and cause of heat as we can have of that of any appearance whatever. Heat is the effect of action, and animal heat is the effect of animal action; and there is no doubt that in every case the two are exactly proportioned to each other, though it may not be so to our observation. For instance, the effect of heat may accumulate in some cases, and it may be carried away in others. Thus, while in consequence of what is called catching cold the perspiration is stopped, the skin is parched, and burning heat is felt over the whole body, even though it should happen to be in an inactive state; on the other hand, a person that perspires freely may undergo great exertion without getting warm. There will be occasion to recur to this subject when we consider the appearances of heat in those portions of creation which are not animated. But here it is satisfactory to learn, that this subject of heat in the living body, which so long perplexed all inquirers, is referable to one of those very general and most sublimely simple laws according to which it is the pleasure of Almighty goodness to govern the earth, and all that it contains and supports.

44. It remains to add some reflections on the wisdom of God, displayed in the structure of the human body. And how eminently is this displayed, first, in the situation of its several parts and members! They are situated most conveniently for use, for ornament, and for mutual assistance. 1. For use. The principal senses are placed in the head, as sentinels in a watch-tower. How could the eyes have been more commodiously fixed for the guidance of the whole body? The ears likewise, made for the reception of sounds, which naturally move up-

ward, are rightly placed in the uppermost parts of the body; and so are the nostrils, as all odours ascend. Again: how could the hands have been more conveniently placed for all sorts of exercises? Or the heart, to dispense life and heat to the whole body? Or the sinks of the body than in the most remote parts of it? 2. For ornament. Not to descend to particulars, what could be better contrived, than that those members which are pairs should be of equal length, and just answer one another on each side? 3. For mutual assistance. So the eye stands most conveniently to guide the hand, and the hand to defend the eye. The same may be said of the other parts: they are all so placed as to direct or help each other. This will clearly appear, if you suppose the position of any of them to be changed. Had our arms been bent backward, what direction could our eyes have afforded us in working? Or how could we even have fed ourselves? Nay, had one arm bent backward and the other forward, half the use of them had been lost; for one could not have assisted the other in any action.

How is his wisdom displayed, secondly, in the ample provision made for the security of the principal parts! These are, 1. The heart, the fountain of life. This lies in the centre of the trunk of the body, covered with its own membrane, the pericardium, lodged within the soft bed of the lungs, encompassed round with a double fence, both of thick muscles and skins, and of firm ribs and bones; besides the arms conveniently placed to ward off any violence. 2. The brain, the principle of all sense and motion, is surrounded with so strong a defence, that it must be a mighty force indeed which is able to injure it. The skull is so hard, thick, and tough, that it is almost as firm as a helmet of iron. This is covered with skin and hair, which both keep it warm, and soften the violence of a stroke. Yet more, a thick and tough membrane hangs loose about it, which often saves it, even when the skull is broke. And lastly, a fine membrane closely adheres, to keep it from quashing and shaking.

How is it displayed, thirdly, in the abundant provision that is made against evil accidents and inconveniencies! To this end, 1. The members which are of eminent use are in pairs. We have two eyes, ears, nostrils, hands; two feet, two breasts, two kidneys; that if one should be rendered useless, the other might serve us tolerably well: whereas, had a man but one hand or eye, if that were gone, all were gone. 2. All the vessels have many ramifications, which send forth twigs to the neighbouring vessels; so that if one branch be cut or obstructed, its want may be supplied by the twigs from the neighbouring vessels. 3. Many ways are provided to evacuate whatever might be hurtful to us. If any thing oppress the head, it can free itself by sneezing; if the lungs, they can cast it off by coughing. If any thing burden the stomach, it can contract itself, and throw it up by vomit. Besides these evacuations, there are siege, urine sweat, and hæmorrhages of various kinds. 4. Whereas sleep is necessary for us in many respects, Nature has provided, that though we lie long on one side, we should feel no uneasiness while we sleep, no, nor when we awake. One would think, the whole weight of the body pressing the muscles on which we lie would be very burdensome. And we find by experience so it is when we lie long awake in the night. Probably this provision is made by an inflation of the muscles, making them soft, and yet renitent, like pillows. That they are inflated during sleep, appears to the very eye, in the faces of children; and from the common experiment, that, if we sleep in our clothes, we must loosen our garters and other ligatures, otherwise we find uneasiness in those parts. 5. Because sleep is inconsistent with the sense of pain, therefore during rest those nerves that convey the motions to the brain which excite the sense of pain are obstructed. "This I myself," says Mr. Ray, "have often experienced, since I have had sores on my legs. Waking suddenly, I find myself at perfect ease for a while; then the pain by degrees returns."

It is displayed, fourthly, in the multitude of intentions God hath in the formation of the several parts, and the multitude of qualifications they require to fit them for their several uses. Galen observes, "that there are in a human body above six hundred muscles, and there are at least ten several intentions in each, and as many qualifications needful: so that about the muscles alone, no less than 6000 ends are to be attended to. The bones are reckoned to be 284. The distinct intentions in each of these are above forty: in all about one hundred thousand. And thus it is, in proportion, with all the other parts, the skin, ligaments, veins, arteries, nerves, glands, humours; but more especially with the members of the body, which, as to the multitude of intentions and qualifications, far exceed the similar parts. And should one of these qualifications fail, great inconvenience would ensue."

It is displayed, fifthly, in the stature of man, so admirably well adapted to the circumstances of his existence. Had man been only a foot or two high, he had been quite disproportioned to every thing round about him. Had he been much larger, he could not well have been supplied with food,—all the edible animals would not have sufficed; and had they too been proportionably larger, the surface of the earth would not have sufficed to feed them.

It is however a common opinion, and has been so ever since old Homer's time, that the people in the early ages of the world were much larger than us; and it is true, we read of some men of a surprising stature; but they were even then esteemed giants. The ordinary stature of men is probably just the same now as it was at the beginning. This may be gathered from the monuments still remaining, particularly the sepulchres of Egypt. The cavities for bodies now visible herein, are little larger than our ordinary coffins: likewise from several embalmed bodies taken out of them it appears, that men are of the same stature now that they were when those sepulchres were formed, which is at least three thousand years ago. Eighteen hundred years ago, the emperor Augustus was five feet seven inches high: Queen Elizabeth was taller by two inches, being five feet nine.

But what a paradox is it, that all men are taller in the morning than in the evening! In a young man the difference is near an inch, try the experiment as often as you please. Does not the difference proceed from hence, that as long as the trunk of the body is in an erect posture, there is a constant pressure on the large cartilages connecting the vertebræ of the spine? So long they gradually contract, and consequently a man grows shorter; but they again gradually expand themselves while we are in a reclining posture.

As to the art of embalming, it appears from a mummy not long since dug up in France, that this was more completely understood in the western world some ages since, that ever it was in Egypt. This mummy, which was dug up at Auvergne, was an amazing instance of their skill. As some peasants were digging in a field near Rion, within about twenty-six paces of the highway, between that and the river Artier, they discovered a tomb that was about a foot and a half beneath the surface. It was composed only of two stones, one of which formed the body of the sepulchre and the other the cover.

This tomb was of freestone, seven feet and a half long, three feet and a half broad, and about three feet high. It was of rude workmanship; the cover had been polished, but was without figure or inscription: within this tomb was placed a leaden coffin, four feet seven inches long, fourteen inches broad, and fifteen high. It was oblong, like a box, equally broad at both ends, and covered with a lid that fitted on like a snuff-box, without any hinge. Within this coffin was a mummy, in the most perfect preservation. The internal sides of the coffin were filled with an aromatic substance mingled with clay. Round the mummy was wrapped a coarse cloth; under this were two shirts, or shrouds, of the most exquisite texture; beneath these a bandage, which covered all parts of the body, like an infant in swaddling clothes; under this general bandage there was another, which went particularly round the extremities, the hands and legs; the head was covered with two caps; the feet and hands were without any particular bandages; and the whole body was covered with an aromatic substance an inch thick. When these were removed, and the body exposed naked to view, nothing could be more astonishing than the exact resemblance it bore to a body that had been dead a day or two before. It appeared well proportioned, except that the head was rather large, and the feet small. The skin had all the pliancy and colour of a body lately dead; the visage however, was of a brownish hue. The belly yielded to the touch: all the joints were flexible, except those of the legs and feet; the fingers stretched forth of themselves when bent inwards. The nails still continued perfect; and all the marks of the joints, both in the fingers, the palms of the hands, and the soles of the feet, remained perfectly visible. The bones of the arms and legs were soft and pliant; those of the skull preserved their rigidity; the hair, which only covered the back of the head, was of a chestnut colour, and about two inches long. The pericranium at top was separated from the skull by an incision, in order to the introducing aromatics in the place of the brain, where they were found mixed with clay. The teeth, the tongue, and the ears were all preserved in perfect form. The intestines were not taken out of the body, but remained pliant and entire as in a fresh subject; and the breast was made to rise and fall like a pair of bellows. The embalming preparation had a very strong and pungent smell, which the body preserved for more than a month after it was exposed to the air. If one touched either the mummy, or any part of the preparation, the hand smelled of it for several hours after. This mummy having remained exposed for some months, began to suffer some mutilations. A part of the skin of the forehead was cut off; all its teeth were drawn out, and some attempts were made to pull away the tongue. It was therefore put into a glass case, and transmitted to the the king's cabinet at Paris.

There are many reasons to believe this to be the body of a person of the highest distinction; however, no marks remain to assure us either of the quality of the person, or the time of his decease. There only are to be seen some irregular figures on the coffin, one of which represents a kind of star.

There were also some singular characters upon the bandages, which were totally defaced by those who had torn them. It should seem that it had remained for several ages in this state, since the first years immediately succeeding the interment are usually those in which the body is most liable to decay.

I cannot better conclude this chapter than by an extract from the late pious and ingenious Mr. Hervey, which may serve for a recapitulation of what has been said, as well as an improvement of it.

"Let us begin with the less adorned but more solid parts, those which support, and which contain the rest. First, you have as ystem of bones, cast in a variety of moulds, in a variety of sizes; all strong, that they may bear up the machine, yet light, that they may not weigh us down: bored with an inward cavity to contain the moistening marrow, and perforated with fine ducts to admit the nourishing vessels. Insensible themselves, they are covered with a membrane, exquisitely sensible, which warns them of, and secures them from the annoyance of any hurtful friction; and also preserves the muscles from being fretted in their action by the hard and rough substance of the bone. They are largest at the extremities, that they may be joined more firmly and not so easily dislocated. The manner of their articulation is truly admirable, and remarkably various: yet never varied without demonstrating some wise design, and answering some valuable end. Frequently when two are united, the one is nicely rounded and capped with a smooth substance, the other is scooped into a hollow of the same dimensions to receive it; and both are lubricated with an unctuous fluid to facilitate the rotation.

"The feet compose the firmest pedestal, infinitely beyond all that statuary can accomplish, capable of altering its form, and extending its size, as different circumstances require. They likewise contain a set of the nicest springs, which help to place the body in a variety of attitudes, and qualify it for a multiplicity of motions. The undermost part of the heel, and the extremity of the sole, are shod with a tough insensible substance, a kind of natural sandal, which never wears out, never wants repair, and which prevents an undue compression of the vessels by the weight of the body. The legs and thighs are like stately columns, so articulated that they are commodious for walking, and yet do not obstruct the easy posture of sitting. The legs swell out towards the top with a genteel projection, and are neatly wrought off toward the bottom: a variation which lessens their bulk, while it increases their beauty.

"The ribs, turned into a regular arch, are gently moveable for the act of respiration. They form a safe lodgment for the lungs and heart, some of the most important organs of life. The back-bone is designed, not only to strengthen the body and sustain its most capacious store rooms, but also to bring down the continuation of the brain, usually termed the spinal marrow. It both conveys and guards this silver cord, as Solomon terms it, and by commodious outlets transmits it to all parts. Had it been only straight and hollow, it might have served these purposes. But then the loins must have been inflexible: to avoid which, it consists of very short bones, knit together by cartilages. This peculiarity of structure gives it the pliancy of an osier, with the firmness of an oak. By this means it is capable of various inflections, without bruising the soft marrow or diminishing that strength which is necessary to support all the upper stories. Such a formation in any other of the solids, must have occasioned great inconvenience. Here it is unspeakably useful, a masterpiece of creating skill.

"The arms are exactly proportioned to each other, to preserve the equilibrium of the structure. These being the guards that defend, and the ministers that serve the whole body, are fitted for the most diversified and extensive operations: firm with bone, yet not weighty with flesh, and capable of performing all useful motions. They bend inwards and turn outwards; they move upward or downward. They wheel about in whatever direction we please. To these are added the hands, terminated by the fingers, not of the same length, nor of equal bigness, but in both respects different which gives the more beauty and far greater usefulness. Were they all flesh they would be weak: were they one entire bone, they would be utterly inflexible: but consisting of various little bones and muscles, what shape can they not assume? Being placed at the end of the arm, the sphere of their action is exceedingly enlarged. Their extremities are an assemblage of fine tendinous fibres, acutely sensible, which notwithstanding, are destined to almost incessant employ, and frequently among rugged objects. For this reason they are overlaid with nails, which preserve them from any painful impressions.

"In the hand we have a case of the finest instruments. To these we owe those beautiful statues, this melodious trumpet. By the strength of the hand the tallest firs fall, and the largest oaks descend from the mountains. Fashioned by the hand they are a floating warehouse, and carry the production of art and nature from Britain to Japan.

"The hand is the original and universal sceptre, which not only represents, but ascertains our dominion over all the elements and over every creature. Though we have not the strength cf the horse, the swiftness of the greyhound, or the quick scent of the spaniel, yet directed by the understanding, and enabled by the hand, we can as it were make them all our own. These short hands have found a way to penetrate the bowels of the earth, to touch the bottom of the sea. These feeble hands can manage the wings of the wind, arm themselves with the violence of fire, and press into their service the forcible impetuosity of water. How greatly then we are indebted to our wise Creator, for this distinguishing, this invaluable member?

"Above all is the head, for the residence of the brain, ample to receive, and firm to defend it. It has a communication with all, even the remotest parts; has outlets for dispatching couriers to all quarters, and avenues for receiving speedy intelligence on all needful occasions. It has lodgments wherein to post sentinels for various offices: to expedite whose operations the whole turns on a curious pivot, nicely contrived to afford the largest and freest circumvolutions.

"This is screened from heat, defended from cold, and at the same time beautified by the hair: a decoration so delicate as no art can supply, so perfectly light, as no way to encumber the wearer.

"While other animals are prone in their aspect, the attitude of man is erect, which is by far the most graceful, and bespeaks superiority. It is by far the most commodious for prosecution of all our extensive designs. It is likewise safest, less exposed to dangers, and better contrived to repel or avoid them. Does it not also remind us of our noble original, and our sublime end? Our original, which was the breath of the Almighty: our end, which was the enjoyment of Him in glory?

"Thus much for the rafters and beams of the house: let us now survey the lodgings within. Here are ligaments, a tough and strong arrangement of fibres, to unite the several parts, and render what would otherwise be an unwieldy jumble, a well-compacted and self-manageable system; membranes, thin and flexible tunicles, to inwrap the fleshy parts, to connect some, and form a separation between others; arteries, the rivers of our little world, that, striking out as they go into numberless small canals, visit every street, yea every apartment, in the vital city. These, being wide at first, and growing narrower and narrower, check the rapidity of the blood. This, thrown from the heart, dilates the arteries, and their own elastic force contracts them, by which means they vibrate against the finger, and much assist both in the discovery and cure of diseases. The larger arteries, wherever the blood is forced to bend, are situate on the bending side, lest, being stretched to an improper length, the circulation should be retarded. They are not, like several of the veins, near the surface, but placed at a proper depth; and hereby they are more secure from external injuries. In those parts which are most liable to pressure, an admirable expedient takes place: the arteries inosculate with each other; breaking into a new track, they fetch a little circuit, and afterwards return into the main road. So that if any thing block up or straiten the direct passage, the current, by diverting to this new channel, eludes the impediment, flows on, and soon regains its wonted course.

"The veins receive the blood from the arteries, and reconvey it to the heart. The pressure of the blood is not near so forcible in these as in the arteries; therefore their texture is considerably slighter —such an exact economist is Nature, amidst all her liberality! In many of these canals, the current, though widening continually, is obliged to push its way against the perpendicular; hereby it is exposed to the danger of falling back and overloading the vessels. To prevent this, valves are interposed at proper distances, which are no hindrance to the regular passage, but prevent the reflux, and facilitate the passage of the blood to the grand receptacle. But these valves are only where the blood is constrained to climb; where the ascent ceases, they cease also.

"Here are glands, to filtrate the passing fluids, each of which is an assemblage of vessels, complicated with seeming confusion, but with perfect regularity. Each forms a secretion far more curious than the most admired operations of chemistry. Muscles, composed of the finest fibres, yet endued with incredible strength, fashioned after a variety of patterns, but all in the highest taste for elegance and conveniency. These are the instruments of motion, and at the command of the will execute their functions quick as lightning. Nerves, surprisingly minute, which set the muscles at work, diffuse the power of sensation through the body, and, upon any impression from without, give all needful intelligence to the soul. Vesicles, distended with an unctuous matter, in some places compose a soft cushion, as in the calf of the leg, whose large muscles, mixed with fat, are of singular service to those important bones. This flanks and fortifies them, like a strong bastion, supports and cherishes them like a soft pillow. In other places they fill up the vacuities, and smooth the inequalities of the flesh. Inwardly, they supply the machine for motion; outwardly, they render it smooth and graceful.

"The skin, like a curious surtout, covers the whole, formed of the most delicate net work, whose meshes are minute, and whose threads are multiplied, even to a prodigy. The meshes are so minute, that nothing passes them which is discernible by the eye, though they discharge every moment myriads and myriads of superfluous incumbrances. The threads are so multiplied, that neither the point of the smallest needle, nor the infinitely finer lance of a gnat, can pierce any part without drawing blood, and causing an uneasy sensation—consequently, without wounding, by so small a puncture, both a nerve and a vein.

"But a course of incessant action must exhaust the solids and waste the fluids, and unless both are properly recruited, in a short time destroy the machine. For this reason it is furnished with the organs and endued with the powers of nutrition. Teeth, the foremost thin and sharp, to bite asunder the food: the hindermost broad and strong, indented with small cavities, the better to grind in pieces what is transmitted to them. But in children the formation of teeth is postponed till they have occasion for them.

"Were the teeth, like the other bones, covered with the periosteum, chewing would give much pain: were they quite naked, they would soon decay and perish. To guard against both, they are overlaid with a neat enamel, harder than the bone itself, which gives no pain in chewing, and yet secures them from various injuries.

"The lips prevent the food from slipping out of the mouth, and, assisted by the tongue, return it to the grinders. While they do this in concert with the cheeks, they squeeze a thin liquor from the adjacent glands. This moistens the food and prepares it for digestion. When the mouth is inactive, these are nearly closed; but when we speak or eat, their moisture being then necessary, is expressed as need requires.

"But the food could not descend merely by its own weight through a narrow and clammy passage into the stomach; therefore, to effect this, muscles both straight and circular, are provided. The former enlarge the cavity, and give an easy admittance; the latter, closing behind the descending aliment, press it downward. But before the food enters the gullet, it must of necessity pass over the orifice of the windpipe, whence it is in danger of falling upon the lungs, which might occasion instant death. To obviate this, a moveable lid is placed, which, when the smallest particle advances, is pulled down and shut close: but as soon as it is swallowed, it is let loose and stands open. Thus the important pass is always made sure against any noxious approaches, yet always left free for the air, and open for respiration.

"The food descending into the stomach is not yet ready for the bowels; therefore that great receiver is strong to bear and proper to detain it, till it is wrought into the smoothest pulp imaginable. From hence it is discharged by a gentle force, and passes gradually into the intestines.

"Near the entrance waits the gall-bladder, ready to pour its salutary juice upon the aliment, which dissolves anything viscid, scours the intestines, and keeps all the fine apertures clear. This bag, as the stomach fills, is pressed thereby, and then only discharges its contents. It is also furnished with a valve of a very peculiar, namely of a spiral, form, through which the detersive liquid cannot hastily pour, but must gently ooze. Admirable construction! which, without any care of ours, gives the needful supply, and no more.

"The nutriment then pursues its way through the mazes of the intestines, which, by a wormlike motion, protrude it, and force its small particles into the lacteal vessels. These are a series of the finest strainers, ranged in countless multitudes all along the sides of the winding passage. Had this been straight or short, the food could not have resigned a sufficient quantity of its nourishing particles, therefore it is artfully convolved and greatly extended, that whatever passes may be sifted thoroughly. As the aliment proceeds, it is more and more drained of its nutricious juices. In consequence of this, it would become hard, and pain the tender parts, but that glands are posted in proper places, to discharge a lubricated fluid. These are smaller or fewer near the stomach, because there the aliment is moist enough; whereas in the bowels, remote from the stomach, they are either multiplied or enlarged.

"The chyle drawn off by the lacteals is carried through millions of ducts, too fine even for the microscope to discover. To this it is owing that nothing enters the blood but what is capable of passing through the finest vessels. It is then lodged in several commodious cells (the glands of the mesentery), and there mixed with a thin diluting lymph, which makes it more apt to flow. Hence it is conveyed to the common receptacle, and mounts through a perpendicular tube into the left subclavian vein. This tube lies contiguous to the great artery, whose strong pulsation drives on the fluid, and enables it to ascend and unload its treasure at the very door of the heart.

"But the chyle is as yet in too crude a state to be fit for the animal functions, therefore it is thrown into the lungs. In the spongy cells of this amazing laboratory, it mixes with the external air, and its whole substance is made more smooth and uniform. Thus improved, it enters the left ventricle of the heart, a strong, active, indefatigable muscle. The large muscles of the arm or of the thigh are soon wearied—a day's labour or a day's journey exhausts their strength; but the heart toils whole weeks, whole months, nay years, unwearied—is equally a stranger to intermission and fatigue. Impelled by this, part of the blood shoots upwards to the head, part rolls through the whole body.

"But how shall a stream, divided into myriads of channels, be brought back to its source? Should any portion of it be unable to return, putrefaction, if not death, must ensue; therefore, the all-wise Creator has connected the extremities of the arteries with the beginning of the veins, so that the same force which darts the blood through the former, helps to drive it through the latter. Thus it is reconducted to the great cistern, and there played off afresh.

"Where two opposite currents would be in danger of clashing, where the streams from the vena cava and vena ascendens coincide, a fibrous excrescence interposes, which, like a projecting pier, breaks the stroke of each, and throws both into their proper receptacle. Where the motion is to be speedy, the channels either forbear to wind (as in the great artery, which descends to the feet), or lessen in their dimensions, as in every interval between all the ramifications. When the progress is to be retarded, the tubes are variously convolved, or their diameter contracted. Thus guarded, the living flood never discontinues its course, but night and day, whether we sleep or wake, still perseveres to run briskly through the arteries, and return softly through the veins.

"But farther. The great Creator has made us an invaluable present of the senses, to be the inlets of innumerable pleasures, and the means of the most valuable advantages.

"The eye, in its elevated station, commands the most enlarged prospects. Consisting only of fluids, inclosed within coats, it shows us all the graces and glories of nature. How wonderful, that an image of the hugest mountains, and the wildest landscapes should enter the small pupil! that the rays of light should paint on the optic nerve, paint in an instant of time, paint in their truest colours and exactest lineaments, every species of external objects.

"The eye is so tender that the slightest touch might injure its delicate frame. It is guarded therefore with peculiar care, intrenched deep, and barricaded round with bones. As the smallest fly might incommode its polished surface, it is farther protected by two substantial curtains. In sleep, when there is no occasion for the sense, but a necessity to guard the organ, these curtains close of their own accord. At any time they fly together as quick as thought. They are lined with an extremely fine sponge, moist with its own dew. Its bristly palisades keep out the least mote, and moderate the too strong impressions of the light.

"As in our waking hours we have almost incessant need for these little orbs, they run upon the finest castors, rolling every way with the utmost ease: which circumstance, added to the flexibility of the neck, renders our two eyes as useful as a thousand.

"The ear consists of an outward porch and inner rooms. The porch somewhat prominent from, the head, is of a cartilaginous substance, covered with tight membranes and wrought into sinuous cavities. These, like circling hills, collect the wandering undulations of the air, and transmit them with a vigorous impulse to the finely stretched membrane of the drum. This is expanded upon a circle of bones, over a polished, reverberating cavity. It is furnished with braces that strain or relax, as the sound is faint or strong. The hammer and the anvil, the winding labyrinth, and the sounding galleries, these and other pieces of mechanism, all instrumental to hearing, are inexpressibly curious.

"Amazingly exact must be the tension of the auditory nerves, since they answer the smallest tremors of the atmosphere, and distinguish their most subtile variations. These living chords, tuned by an almighty hand, and spread through the echoing aisles, receive all the impressions of sound, and propagate them to the brain. These give existence to the charms of music, and the still nobler charms of discourse.

"The eye is useless amidst the gloom of night. But the ear hears through the darkest medium. The eye is on duty only in our waking hours: but the ear is always accessible.

"As there are concussions of the air, which are discernible only by the instruments of hearing, so there are odoriferous particles wafted in the air, which are perceivable only by the smell. The nostrils are wide at the bottom that more effluvia may enter, narrow at the top, that when entered they may act more strongly. The steams that exhale from fragrant bodies are fine beyond imagination. Microscopes that show thousands of animals in a drop of water, cannot bring one of these to our sight. Yet so judiciously are the olfactory nets set, that they catch the vanishing fugitives. They imbibe all the roaming perfumes of spring, and make us banquet even on the invisible dainties of nature.

"Another capacity for pleasure our bountiful Creator has bestowed, by granting us the powers of taste. This is circumstanced in a manner so benign and wise as to be a standing plea for temperance, which sets the finest edge on the taste, and adds the most poignant relish to its enjoyments.

"And these senses are not only so many sources of delight but a joint security to our health. They are the inspectors that examine our food and inquire into the properties of it. For the discharge of this office they are excellently qualified and most commodiously situate; so that nothing can gain admission till it has passed their scrutiny.

"To all these, as a most necessary supplement, is added the sense of feeling. And how happily is it tempered between the two extremes, neither too acute, nor too obtuse. Indeed all the senses are exactly adapted to the exigencies of our present state. Were they strained much higher, they would be avenues of anguish, were they much relaxed, they would be well nigh useless.

"The crowning gift which augments the benefits accruing from all the senses is speech. Speech makes me a gainer by the eyes and ears of others;

by their ideas and observations. And what an admirable instrument for articulating the voice, and modifying it into speech, is the tongue? This little collection of muscular fibres under the direction of the Creator is the artificer of our words. By this we communicate the secrets of our breasts and make our very thoughts audible. This likewise is the efficient cause of music; it is soft as the lute, or shrill as the trumpet. As the tongue requires an easy play, it is lodged in an ample cavity; it moves under a concave roof, which gives additional vigour to the voice, as the shell of a violin to the sound of the strings.

"Wonderfully wise is the regulation of voluntary and involuntary motion. The will in some cases has no power: in others she is an absolute sovereign. If she command, the arm is stretched, the hand is closed. How easily, how punctually are her orders obeyed! To turn the screw, or work the lever, is laborious and wearisome. But we work the vertebra of the neck with all their appendent chambers; we advance the leg with the whole incumbent body: we rise, we spring from the ground, and though so great a weight is raised, we meet with no difficulty or fatigue.

"That all this should be effected without any toil, by a bare act of the will, is very surprising. But that it should be done, even while we are entirely ignorant of the manner in which it is performed, is most astonishing! Who can play a single tune upon the spinnet, without learning the difference of the keys? Yet the mind touches every spring of the human machine with the most masterly skill, though she knows nothing at all of the nature of her instrument, or the process of her operations.

"The eye of a rustic, who has no notion of optics, or any of its laws, shall lengthen and shorten its axis, dilate and contract its pupil, without the least hesitation, and with the utmost propriety: exactly adapting itself to the particular distance of objects, and the different degrees of light. By this means it performs some of the most curious experiments in the Newtonian philosophy, without the least knowledge of the science, or consciousness of its own dexterity.

"Which shall we admire most, the multitude of organs; their finished form and faultless order—or the power which the soul exercises over them? Ten thousand reins are put into her hands, and she manages all, conducts all, without the least perplexity or irregularity. Rather with a promptitude, a consistency and speed, that nothing else can equal.

"So fearfully and wonderfully are we made! Made of such complicated parts, each so nicely fashioned, and all so exactly arranged; every one executing such curious functions, and many of them operating in so mysterious a manner! And, since health depends on such a numerous assemblage of moving organs; since a single secretion stopped may spoil the temperature of the fluid, a single wheel clogged may put an end to the solids: with what holy fear should we pass the time of our sojourning here below. Trusting for continual preservation, not merely to our own care, but to the almighty hand which formed the admirable machine, directs its agency, and supports its being."

CHAPTER II.

OF THE NATURAL STATE OF THE HUMAN BODY.

1. THAT is the natural state of the human body wherein all parts of it duly perform their natural operations. The chief of these are, the circulation of the blood by the heart and its vessels; respiration by the lungs; assimilation and nutrition by the digestive organs; secretion and excretion by their various organs; sensation and motion; and obedience to the mind on the part of the body. The natural state depends of course on there being a proper balance among all those operations or functions; and not only that no one of them shall be either in excess or in deficiency as compared with the rest, but also that the whole shall have that moderate degree of action which consists with the grand object of a body in the natural state, a long and active life. If the natural operations, though in perfect harmony with each other, are over vigorous in their action, the tendency evidently is to wear out the body, and thereby shorten the

period of its existence. If, on the other hand, those operations are too languid, the body is incapable of that energy which is necessary to a due performance of the duties of life, and the full acquirement of that knowledge and readiness in action, which are necessary to the right performance of those duties. Also, if the tardiness of the operations is beyond a certain limit, the very slowness of life may wear it out in like manner as in excessive quickness.

There are very many things connected with those operations concerning which we have no knowledge whatever, our knowledge of them all is exceedingly imperfect; and, therefore, in speaking of them, it behoves us to speak with the utmost caution, and to advance what we state rather as probable conjectures, than as truths which are known to us in all their circumstances.

2. The way in which the blood circulates has been already noticed; and the fact of its circulation is now so well established and so generally admitted as to require no proof.

The quantity or period of circulation in the healthy state of the body when full grown and undecayed, was calculated by Blumenbach, and there is no reason to doubt the accuracy of his calculation. The rapidity of pulsation varies in different individuals even when in perfect health, according to the different energies of the system; but it may, on the average, be taken at seventy-five beats or pulsations of the heart in a minute. The whole mass of blood in the body of a man of middle size, is about thirty-three pounds; and from the size of its chambers, the heart discharges two ounces of blood into the systematic arteries at each contraction. Thus the whole mass of the blood will circulate through the body in about two minutes and thirty-six seconds; and it will make the complete tour of the body nearly twenty-three times an hour, or more than five hundred times in the course of the twenty-four hours. This may be considered as the rate at which the healthy body requires to be repaired; and it is truly wonderful that a frame so complicated, and requiring five hundred repairs throughout in the course of every day, should last even for threescore and ten years. Every pulse of the heart sends the blood to every part of the body; and thus there is necessarily a repair of every part, and a passage through every blood-vessel, whether artery, vein, or capillary, and however minute, at each of those pulsations.

From this we can easily understand how, when the pulse is slow, the body should be languid; because it does not get the stimulating repair of the blood often enough. On the other hand, we can as easily see why, when the pulse is unnaturally increased, the body must be over-laboured by its own internal working, and thereby thrown into a state of heat and fever.

We have collateral illustrations of this in those animals which have red blood, as man has, but different degrees of circulation. Those which have the circulation very rapid, are warm in their temperaments, and their lives are in general short in proportion to the strength of their frames; while those which have the circulation very slow, are cold, but have their lives of long duration. In these cases, however, the rate of pulse is wisely adapted to the structure and habits of the animal, and we are not to consider any one rate as a diseased one, as we do in the human body, when it rises above or falls below the average rate of health.

The next point to be considered is the means by which the blood is made to circulate; but in this there are some difficulties which render it necessary that we should begin with the details, because we cannot reach the general and original principle.

That the heart is the principal instrument in producing motion of the blood in the arteries, cannot be doubted. The heart is wholly muscular; and a muscle is the only organ in the body with which we are acquainted that has the power or faculty of *originating* motion. When we use the word "originating," we must not be understood as applying it to the *first* origin; for the question still remains. "What moves the muscle?" and if it shall be said that "the nerve" or *any other material thing* moves it, the question still remains, "What moves the nerve or other material thing?" Therefore, though we argue ever so carefully, and fancy we go ever so far, we cannot get one jot beyond the simple fact that "the muscle moves." No doubt it moves by the application of some stimulus, as is proved by the motion of dead muscles when galvanic action is applied to them; but this action belongs to the same mysterious class as that which we call life; and therefore the only other expression that we can rationally use is, that "life moves the muscle," or that the muscle of a living animal moves of its own accord, or at the will of the animal, but that the muscle of a dead animal does not; and this is only saying in other words that the muscle moves. It is thus that the energies of life lie wholly beyond the range of our knowledge, though the manner of their working, which is visible to us, is wonderful beyond all comprehension, and instructive beyond all that we can observe in the works of man. We see as it were the finger of God, or the effect of its power, in the most trifling motion of the minutest fibre in the muscular part of our frame.

A muscle differs from every other part of the body in this, that it has a motion two ways. A membrane, a tendon, the coat of a vessel, or any other part which is not bone, has motion one way, but only one, and this motion is not a motion of life. It depends upon the elasticity of the part, and this is a property which is common to all matter, and to matter in every state, whether alive or dead, though differently manifested in different kinds and states of matter. But elasticity is characteristic of death rather than life, for it means the preservation of one particular state. In the case of a membrane or other member of the body, it means the preservation of a certain length or a certain breadth. If it is stretched beyond this, it contracts when the force that stretched it ceases to act, as if it is compressed into less measure than this, it expands again when the compressing force is withdrawn. The parts of the body which are elastic retain their elasticity after death, until the power of dissolution alters their state, which is in itself a proof that the elasticity of those parts of the body is a property of mere matter, and not a function of the life.

But it is different in the muscle: the muscle in its integrant part is always a fibre; that fibre has of itself a tendency to contract, and after contraction to relapse; and it is this contractibility which is the primary motion of the muscle. It is produced by some stimulus, but what this stimulus is we are unable to say, further than that it is a function of life. Some say that it depends on the healthy state of the nerve connected with the muscle, and others on the healthy state of the blood, and it probably depends on both; but still the healthy states of these are nothing more than parts of the healthy state of the living action, so that such explanations leave us precisely where they found us.

But by whatever the contraction of the muscular heart may be occasioned, there is no doubt that this contraction is the cause of the blood moving along the arteries; for it appears that the power which they have is elasticity much more than muscular action, if indeed it be muscular action at all; and the contraction of the arteries is a resistance to that impulse which the blood receives from the heart, and not an assistant to it.

The force of the heart in propelling the blood through the system has been variously estimated, but the estimates, proceeding entirely upon the properties of dead matter, are very vague. This is shown by their discrepancy. Borelli estimated it at a hundred and eighty thousand pounds' weight, which is equal to the strength of many horses. Keill, on the other hand, made it five ounces and a half, or a half million times less than Borelli. The estimate of Hailes, which is about fifty pounds' weight, is perhaps as near the truth as guess-work can come, for it is little better than guess-work. The next question is, by what means does the blood return from the extremities? and here it is evident that the muscular action of the heart has much less influence than in the case of the arteries, for the auricles of the heart merely open to receive the returning blood, and their contraction, which is their muscular force, propels that blood into the ventricles. The veins, too, are much less elastic than the arteries, and therefore their structure cannot contribute much to the return. But the general action of the muscles throughout the body tends greatly to this purpose, by compressing those veins which are in contact with them; and this is one of the reasons why exercising the body increases the circulation. That this takes place in the veins near the skin, by the contraction of the muscular part of the skin, is beneficially proved in many cases. Bathing and washing with cold water, and exposure to pure air, and rubbing, and brushing, all tend to tighten the skin by the contraction of its muscles; and it is well known that all these, applied at proper times, and within due limits, quicken the circulation, and bring a glow of heat over the body, making it feel more alive and vigorous, and capable of performing every function. So also when a limb or other part of the body is swollen by the lagging blood, and even after the serous part of that blood has partially exuded into the cellular tissue, friction has often a very powerful effect, and so also has any application which makes the skin contract and tighten. These things may be done to excess, however, and the return of the blood may be made too rapid for the lungs, and also in proportion to the supply brought to the arteries. The effect of this is twofold: the lungs are excited beyond what they can bear, and heat and inflammation of those delicate organs, and also of the membranes which line the breathing passages, are the necessary consequences. Then, on the other hand, the drain upon the parts of the body by the return of serous blood being greater than the supply by arterial, the fat is taken up to supply the deficiency, the cellular substance becomes loose, the muscles lax, and the whole body exhausted and emaciated. Such is the consequence of a severe and inveterate cold; such is in many cases the incipient cause of consumption; and such is the state of the body under many other diseases.

The circulation in the fœtus, which has no respiration, differs from that after birth; but this will be more briefly and easily explained when we come to speak of the production of the human body in the ordinary course of generation.

3. Respiration is performed by receiving the air into the lungs, and breathing it out alternately. In the former, the cavity of the breast is enlarged by the sinking of the diaphragm and the erection of the ribs, through the force of the muscles placed between them. The general manner in which this operation is performed, and its general effect upon the body, have been mentioned already; so that all we have to notice now is the quantity of respiration, and the way in which it may be supposed at first to begin, with such further remarks on its connexion with the temperature and healthy action of the body generally, as our limits will permit.

According to what appear the best observations, and even those are liable to great uncertainty, it is probable that about a seventh part of the contents of the lungs is discharged at every natural expiration of the breath. In the ordinary condition of the body, a strong effort will greatly increase this quantity, and bring it up to two-thirds, or even more. This is produced by strong contraction of the chest, by compressing the ribs and elevating the diaphragm; and any one who makes the trial, will find that, after a violent expiration of this kind, a lengthened inspiration is necessary, but does not require the same voluntary effort; so also when a violent inspiration is made by distending the chest to the utmost, a lengthened expiration follows, but also without any great voluntary effort. From this it is evident that, besides the voluntary action of the muscles in respiration when we make an effort, there is an involuntary motion, which, like the pulsation of the heart, goes on independently of our will and of our knowledge in healthy states, and against our will in states of disease.

Some part of this is doubtless owing to the elasticity of the cells of the lungs, and the cartilages connected with the thorax and diaphragm, which elasticity has a natural tendency to preserve a certain capacity in the cells of the lungs, and which actually so preserves it even after death. The cause which distends the lungs beyond this is muscular, either with or without an effort; but the cause which makes them contract is a more mysterious matter; and perhaps the simplest explanation that we can give of it is referring it to that general principle in the living body, by which of itself it endeavours to resist or escape from danger.

The elasticity of the lungs and other organs of respiration, giving the cells a certain capacity without any muscular effort, throws some light upon a point involving much difficulty, and respecting which a variety of opinions have been advanced. This point is,—how does breathing at first commence? We know that no air has access to the fœtus in the uterus, for there it is inclosed in impervious membranes, and surrounded by fluids within those membranes. It can receive no nourishment from the common process of digestion, because all that reaches it is matter furnished by the mother, and therefore already assimilated; though between the mother and the child there is a veil of mystery which we cannot draw aside, and through which we cannot see.

But from its position in the uterus, the thorax and lungs of the child are under a state of constant compression, so that probably no blood finds its way into the more minute pulmonary vessels, even to circulate without being changed. But when the child is released from its prison-house by birth, and comes into the free air, the elasticity of the thorax and lungs has freedom to act; and in proportion as the cells are expanded, the air presses in by the mouth and nostrils, until the cells of the lungs are distended by a pressure equal to that upon the external surface of the body. It is probable that the distension may go a little beyond this, because all motions of matter, being performed in time, require time to be stopped, which carries them beyond the equilibrium of what resists them; and this enables the resistance to react and pass the equilibrium the other way. Thus, when the natural expansion of the lungs and thorax commences, the air begins to rush in, and continues to do so until the lungs are expanded; and the momentum which the air thus acquires, expands them beyond their natural dimensions. But this expansion beyond their natural dimensions takes place in a manner well worthy of attention; because it involves a principle which we can carry with us through the whole moving creation, whether living or dead. Beyond their natural size the cells resist more and more, just as a spring or bow does when farther bent; and for this reason the power of the air to expand gradually becomes less and less. Thus at the end of the expansion, the cells of the lungs have accumulated a power of resistance, while the expanding power of the air has been diminishing until it becomes extinct; and the power of resistance is then free to act, and does act, until it turns the expansion so far into a contraction.

It is true that this is only a mechanical explanation, and has nothing to do with life; but it is equally true, that the air and the substance of the body are matter, partaking of the properties of matter, and obedient to its laws in so far as those laws are not controlled by the living functions; and, consequently, whenever there is a function of the body in which the mechanical properties of matter can take effect, they will take effect. If these were not the case, all weights would feel equally heavy, and the severest labour would fatigue us no more than if we were stretched at ease on the softest couch.

Nor is it less wonderful, less overwhelming to our common understanding of things, to find that this mechanical effect of breath upon an infant is an instance of the very same law which sustains the earth, the planets, the sun, and all the mighty systems of the heavens in their courses. It is the reaction of the sun's attractive influence upon an orbital motion, which has been continually diminishing, that brings back the planet when most remote from the sun; and it is the advantage gained by a motion that has been constantly increasing, which enables the planet to overcome the attractive influence of the sun, when at the shortest distance from that luminary. Thus, as there is one God, so there is one creation; and though the periods of their years are differently numbered, many may read in the book of the heavens the interpretation of the laws of his mortal body, in so far as those laws are mechanical.

What follows after this first mechanical admission of the atmospheric air, and first and every limited reaction of elasticity in the breathing apparatus of the infant, is more of a mystery; because life, and muscular action as dependent upon life, blend with it in that singular stage of the first inhalation, in which the simple atmospheric fluid becomes the breath of life to the infant.

From some experiments which have been made, there is reason to conclude that, if air containing oxygen is applied to venous blood, that blood acquires the scarlet colour, and probably along with that the other properties of arterial blood; but if nitrogen, which is the other ingredient of the atmosphere, and especially if carbonic acid gas is applied to arterial blood, that blood assumes the dark colour, and probably along with that acquires the qualities of venous blood. In these experiments, it was found that making the lungs to act after death, had the effect of bringing blood to them and sending it to the heart; and if fresh air was applied, the same colour was produced as is produced in the living body; but if the same air was repeatedly returned, the blood passed from the lungs with its dark colour unaltered.

But though the results of these experiments are curious, they throw no light on the action of the living body. They did not in the least bring back the living action, and the play of the lungs was thus merely mechanical, produced by the reaction of the mere elasticity upon the air forced into the lungs by repeated efforts of the apparatus, whereas without the efforts of the apparatus the elasticity would have soon come to a state of repose, and the stillness as well as the insensibility of death would have taken place. Still, these experiments are curious, as throwing some light upon the means by which parties who have been drowned or otherwise suffocated, and are found and operated on in time, may be restored to animation. It would be foreign to the nature of this compendium to enter into the details of those matters, but we may remark that, in these recoveries, respiration always precedes a perceptible pulse at the wrist, and that pulsation there always precedes the awakening of the patient to sensibility.

4. The progress of the food from the time it is taken into the mouth through the different stages of its change into chyme in the stomach, and into chyle on its progress to the thoracic duct, has been mentioned in the preceding chapter; and, indeed, this progress is easily traced. But who shall tell by what means those changes take place? Who shall explain by what singular agencies the grass of the fields is turned into oxen, oxen and sheep into lions and other ravenous beasts, and the various matters upon which mankind feed, into the living substance of the human body? These are mysteries beyond our reach; and it forms one of the most extraordinary properties of a living crea-

ture, whether animal or vegetable, that it has in itself the power of changing other substances into its own substance. This is not done without mixing certain fluids peculiar to the body itself with the new substance which it takes in as food; and in the case of man, the different fluids of the body which mingle with the food in its progress are very numerous, but what portion of them is retained in the assimilating and assimilated food, and what portion is ejected from the body along with the refuse of the food, we are unable to say, though it is highly probable that one portion of each goes the one way, and another portion goes the other.

Moistening the food with saliva while it is undergoing the process of mastication, appears to have more beneficial influence not only upon digestion but upon the whole system, than many are aware of. Thirst may be allayed by chewing a hard biscuit, or even by bruising a leaden bullet between the teeth. In short, anything which requires such an action as to cause a great natural discharge from the salivary glands, has a beneficial effect upon the system.

In the stomach, the food mingles with the gastric juice; and a peculiar twisting motion of the stomach, which is called the vermicular motion, because it somewhat resembles the wriggling of a worm, is understood to promote the union of this juice with the food, and the consequent conversion of the food into chyme. Besides the solvent power of this juice, it has a wonderful antiseptic power; for in those animals which feed upon substances in a putrid state, as many wild beasts are compelled to do, the offensive smell goes off as the process of digestion proceeds; and though the smell of chyme is peculiar, it is not disagreeable even in the most foul and putrid feeders.

There have been many attempts to explain in what way this change takes place. Hippocrates and his followers said "by concoction," much in the same manner as substances are reduced in a Papin's digester. But this is saying nothing; and the illustration does not apply, for there are few substances which would be much altered in a Papin's digester, if its temperature were no higher than that of the human body. Others have said "putrefaction;" but this is impossible, as the tendency of the stomach is to prevent, and even counteract putrefaction. When it was the fashion to consider all the actions of the body as being mechanical, it was supposed that digestion was a sort of grinding; but this also is inconsistent with the structure of the stomach. Chemical solution was proposed by Spallanzani, but it will not explain the whole process, and thus in reality it explains nothing. The action of the vital principle, and that of the nerves, have both in turn been advanced for the same purpose; but we know no specific action of the vital principle, and no vital principle but the fact of the body being alive; and though, in Dr. Philip's experiments, digestion ceased when the nerves supplying the stomach were divided, yet the immediate cause seemed to be that there was no longer a supply of gastric juice; and this rendered it probable that the action of the nerves has much more connection with secretion, at least in the stomach, than with the digestive process. Fermentation has also been propounded, and it explains some of the operations, but, like all the rest, it does not explain the whole. We must therefore be contented with reckoning this change of the food among those processes which we do not understand; and if we do not understand it in this early stage, we cannot hope to be better informed after it has become more complicated by receiving bile from the liver, the pancreatic juice, and probably other fluids secreted or absorbed, with which we are but little acquainted.

The lymphatics bring their contents from all parts of the body, and discharge them into the thoracic duct in like manner as the lacteals bring the chyle to that vessel. They all, both lymphatics and lacteals, pass through one or more glands before they arrive at the thoracic duct, but what changes their contents undergo in those glands it is not easy to say. It may be that the cellular tissues of the body are nourished by the lymphatics, and that the muscles are nourished by the blood, which alone contains fibrin; and in this case, while the lacteals bring the new supply into the thoracic duct, the lymphatics may convey thither the waste of all those tissues of the body which are not muscular. This, however, though not improbable, is only conjectural.

5. All the secretions are, as the name imports, secret operations, of which we can say little more than that they are produced by certain organs, and that their healthy quality depends upon the healthy state of those organs. Of the excretions some have been noticed, and others are so well known as to require no notice.

6. As without respiration, circulation, and nutrition, we cannot live at all, so without sense life would be like death. In every sensation there is, 1. An outward object. 2. Its action in the organ

of sense. 3. A perception of it in the mind. The action of the object on the organ, is by means of the nerves communicated to the brain. And then, not otherwise, the perception follows. But how, none but He that made man can explain.

When we speak of sensation and of an organ of a particular sense, we do not mean that the organ is endowed with absolute perception ; for why the eye sees, the ear hears, or any other organ communicates an impression, is not in the least explained, though we understand the mechanical construction of that organ. This construction is formed for acting upon the object of sense, or rather for being acted upon by it ; but what connection there is between this action, and even the animal perception, which we may consider as antecedent to the mental one; and capable of being produced without it, as is done in the case of the other animals, we know not. Perhaps, however, and indeed it is highly probable, there is a general sense existing in the muscles of the body, and in fact of all parts of it which are sensible to pain, of which what we call the senses, that is, those having local organs, are merely local modifications. With this precaution we may briefly enumerate the senses in those terms in which their operations are commonly expressed.

7. In sight, the action of the organ is performed just in the manner of that in a camera obscura. The rays of light reaching from the surface of bodies to the eye, variously penetrate the coats and humours of it, and paint on the bottom of the eye the images of the things which we see. This is communicated by the optic nerve to the brain, and then the perception, which is properly sight, fol-

lows. But the eye has many advantages above a camera obscura: not only as it can be moved various ways, by the help of its muscles, but also as the pupil, by the help of the iris, is instantly either dilated or constringed, according to the degree of light. The eye likewise accommodates itself to the various distances of the objects, the bottom of the eye approaching to or receding from the crystalline humour, as the object is nearer or farther off.

8. Sound is a tremulous motion of the air, produced by the stroke or collision of bodies. Hearing is performed in the following manner: The undulating air enters the outward cavity of the ear, and then strikes upon the drum; from which the motion is communicated to the little bones within, and the air contained in the inner cavity. This by means of the nerve conveys it to the brain, and then follows the perception which we term hearing.

9. The fine effluvia which spread every way from odorous bodies, ascending with the air into the nostrils, variously twitch the filaments of the olfactory nerves, according to the variety of their natures. When this motion is by those nerves communicated to the brain, the perception follows which is called smelling.

10. It was observed before, that the surface of the tongue and palate are beset with small papillæ, which are no other than fine ramifications of the gustatory nerves. These are variously moved by the particles of meat and drink. And this motion being by that nerve transmitted to the brain, that perception arises which we style tasting.

11. The organ of feeling or touch is the skin in

general, with which innumerable nervous papillæ are interwoven, which being moved by the slightest touch of other bodies, convey that motion to the brain. But these papillæ abound in all the extremities, particularly the palms of the hand and the tips of the fingers. And hence it is, that the sense of feeling is far more exquisite in those than in other parts.

12. Nearly allied to the senses are the natural appetites, particularly hunger and thirst. The usual way of accounting for them is this: when the food, now reduced to a pulp, is expressed out of the stomach, it is of course contracted by its muscular coat. This causes the inner coat to lie in folds; which, by means of the peristaltic motion, rubbing lightly on each other, occasion the uneasy sensation which we term hunger. This is felt first in the upper orifice, which is first evacuated. But as by degrees the rest of the contents are expelled, this rubbing of the membranes on each other spreads over the whole stomach, and renders our hunger more urgent.

This uneasy sensation is increased by the acidity, which the blood in the arteries of the stomach contracts through long abstinence, its soft balsamic parts having been all drawn off. Likewise its velocity is considerably augmented, when we have not eaten for some time.

Hence it is that hunger, if it continues long, will occasion a violent fever; that young persons, and those who labour hard, or are of a bilious constitution, are soonest hungry; whereas those whose humours are thick and viscid, are not so soon incommoded therewith.

Hot vapours ascending from the stomach, and drying the throat and mouth, are supposed to be the occasion of that uneasy sensation which we term thirst. I say are supposed; for I apprehend nothing can be known with any certainty upon this head. In like manner, it is supposed that we are then awake when the nerves are braced, and filled with animal spirits; and that when they are unbraced and empty, we sleep.

13. But who can give any satisfactory account of sleep? Some ascribe it to the stoppage of the nerves: some to the quiescency, and others to a deficiency of the animal spirits. The truth is, we are ignorant of the whole affair; and no more understand sleep than we do death.

But this we know, that during sleep several functions are suspended, the organs of sense are at rest, the muscles are quiescent, so that hardly any action takes place in them. The fibres of the nerves are little changed, and an equilibrium obtains throughout. There is no difference of pressure on the vessels, nor of velocity in the contents, which circulate equally through all the canals. Meantime, all disturbing causes being at rest, the wasted fluids are restored, and the particles supplied, which were worn off the solids.

We may observe, farther, that when the head is hot and the feet cold, we cannot sleep; that perspiration is twice as great while we sleep as while we are awake; that too much sleep makes the senses dull, the memory weak, and the whole body listless; that sleep will for a considerable time supply the place of meat and drink; that a fœtus sleeps always, children much, youths more than adults, and they more than old men.

To speak a little more particularly. While we are awake there is a continual motion of the voluntary muscles, of the parts subservient to sense and to the affections, all of which stimulate the nerves, blood-vessels, and heart. Thus the finer parts of the blood are continually wasted, whence weariness ensues, and if the vigilance be continued, a feverish heat and sensible loss of strength.

As the night advances a weight falls on the large muscles and their tendons, and the feelings also become heavy; the powers that hold the body erect begin to shrink from their office; the eyelids close, the head nods, and we take less notice of outward objects till at length all the thoughts are in confusion, and a sort of delirium ensues, whence there is a transition to sleep, not known, to us. This is hastened by darkness, composure of mind, and absence of irritation from all parts of the body.

Again: whatever weakens the natural powers inclines to and increases sleep; such as loss of blood, cooling medicines, yea the cold of the external air,—add to these, whatever calls off the quantity of blood returning to the heart, as warm bathing of the feet, a plentiful ingestion of food into the stomach; likewise whatever lessens the motions of the fluids, whether in the brain or stomach, heart or arteries. On the contrary, some hot medicines induce sleep, by causing a greater afflux of blood to the brain. Some fevers have the same effect, as also fatness, and whatever else retards the venal blood. In all these cases, the blood collected in the head compresses the brain, so as to lessen the action of the nerves.

Sleepiness is likewise produced by any compression of the brain, whether from extravasated blood, a depressed part of some bones, or a collection of serous water within the ventricles. Sleep, therefore, sometimes arises from a defect of action, always from a collapsing of the nervous fibres, through which certain energies pass from their fountain to all parts of the body.

It is hindered by intense thought, pain of body, and strong emotions of mind, all which urge the circulation on, and prevent the nervous fibres from relaxing.

In sleep the heart is gradually restored from its quick and almost feverish pulsation to its slow and calm motion; the breathing is slower and smaller, the motion of the stomach and intestines, the digestion of the aliments, and the progression of the excretory matter, are diminished. At the same time the thinner juices move more slowly, while the more gross are called together, the fat is accumulated in its cells, and the nutritive particles adhere more plentifully to the inner surfaces of the small vessels, and the sides of the fibres. Thus, while the fluids are secreted with a less consumption, they are by degrees accumulated in the brain, so as to distend and fill the collapsed nerves; and then we awake out of sleep.

Let us consider, in another view, these remarkable incidents of our frame, sleep and dreams, so remarkable, that they are a kind of experimental mystery—a standing miracle. Behold the most vigorous constitution when resigned to the slumbers of the night: its activity is oppressed with indolence, its strength suffers a temporary annihilation. The nerves are like a bow unstrung, the whole animal like a motionless log. Behold a person of the most delicate sensations and amiable dispositions. His eyes, if wide open, discern no light, distinguish no objects. His ears, with the organs unimpaired, perceive not the sounds that are round about them. The exquisitely fine sense of feeling is overwhelmed with an utter stupefaction. Where are his social affections? He knows not the father that begat him, the friend that is as his own soul. Behold the most ingenious scholar, whose judgment traces the most intricate sciences, whose taste relishes all the beauties of composition. The thinking faculties are unhinged, and, instead of close connected reasoning, there is nothing but a disjointed huddle of absurd ideas. Instead of well-digested principles, nothing but a disorderly jumble of crude conceptions.

Yet no sooner does he awake, than he is possessed of all his former endowments. His sinews are braced and fit for action, his senses alert and keen. The frozen affections melt with tenderness. the romantic visionary is again the master of reason. And, what is beyond measure surprising, the intoxicated mind does not work itself sober by slow degrees, but in the twinkling of an eye is possessed of all its faculties! Why does not the numbness which seized the animal powers chain the limbs perpetually? Why does not the stupor that deadens all the senses hold fast its possession? When the thoughts are once disadjusted, why are they not always in confusion? How is it that they are rallied in a moment and reduced from the wildest irregularity to the most orderly array? From an inactivity resembling death, and from extravagancies little differing from madness, how suddenly is the body restored to vigour and agility!

How instantaneously is the mind re-established in sedateness and harmony! Surely this is the Lord's doing, and it is marvellous in our eye!

14. That all motion is performed by means of the muscles, all men are now agreed; and it is supposed that the motions of the muscles proceed from the influx of the animal spirits, which, entering them by means of the nerves, swell and shorten the belly of the muscle, and thereby draw the extremities together, and move the parts connected therewith. But all this likewise is mere conjecture: God only knows his own work.

15. That some motions are voluntary, and some are not, is another amazing proof of the Creator's wisdom. Those which are absolutely necessary for the conservation of the machine, as the beating of the pulse and the circulation of the blood, go on by a kind of mechanic law, which no way depends upon our will; while a thousand other motions begin and end by a single act of our will, when we please. But how this bodily motion is connected with that act of our mind, who is able to explain?

16. There is a manifest congruity between the stature of a man and his age during the time of his growth; and as five feet and a half may be thought the ordinary height of man, so may seventy years the ordinary period of his life; yet some vastly exceed in both respects. Many instances are recorded in which individuals of the human race have far exceeded the ordinary dimensions; and there are some nations, and some districts in even the same country, where the average size of the body much exceeds that in other districts. It does not appear, however, that there is any particular advantage in this; and a very little consideration

will show why there should not. Quantity of matter is not in itself a source of active strength, but rather a load upon the acting powers. It is a well-known fact, that when a regiment of soldiers is on a long march, in which each man is allowed to exert himself as his strength will allow, the smaller sized men, all other circumstances being alike, always have the advantage in the end. The usual way of beginning such a march is with the grenadiers, who are tall and heavy men, in front; but though there is no great difference in the weight of the arms and other appointments with which they are loaded, after a few hours, the small men, who occupy the centre of the regiment, find their way to the front, and the grenadiers are found in the rear.

It is the same in the case of all other animals. The dray horses in London, which are of such bulk, that they are sometimes called English elephants, can pull very powerfully for a short time; but they could not bear the continued draught of a coal wagon for a quarter of a day, while in a mail coach they would be comparatively useless.

As little has this unusual size anything to do with the talent or ability of the party, for though there are exceptions, it is in general found that men of moderate size are both the most active and the most intelligent; and there are some instances in which very small men are remarkable not only for the vigour of their minds, but for the strength and durability of their bodies. When, however, the body is beneath a certain size, it appears that there is something defective in it, and such individuals are generally short lived. They are so, frequently, from disproportion in different parts of the body, as, for instance, in the head, or some other part, being too large in proportion to the rest; and this destroys that equality of action in the different parts of the body which seems to be essential to continued health and long duration of life.

With regard to those individuals whose lives are extended far beyond the ordinary period of threescore and ten years, no particular judgment can be formed. Some of them have been diseased in their youth; others healthy throughout the whole period of their lives; some have been possessed of ability, and others have been comparatively dull. The generality have been temperate through life; but there are exceptions even to this; and, among old soldiers especially, there are not wanting instances of great age in those who have even indulged in the use of spirituous liquors. Generally speaking those long-lived persons have been of moderate temperament, and not much liable to be excited by the stronger passions, or susceptible to anything calculated to throw unequal labour upon different parts of the system. This subject is, however, one upon which it is hard, and even impossible, to come to anything like a general conclusion,

17. The relation of the body to the mind is a subject of still greater difficulty, and it is easy to see why this should be the case. We know something of the matter of the body, and also of its parts; but of the substance of the mind we know nothing, and the very notion of its being an immortal spirit, incapable of dissolution or death, forbids us from supposing, or even imagining, that

it can be in any way made up of parts. Therefore we cannot suppose that the mind in itself can in any way partake of the imperfections or disease of the body; but that, as it is from its nature exempt from death, it must be independent of all those circumstances which give warning of dissolution in its mortal tenement. It requires no nourishment, because no part of its substance can be exhausted; it requires no rest, because no part of it can get weary; and it requires no sleep, because no part of it can get worn out. Therefore, all those cases in which we attribute fatigue to the mind, are really instances of fatigue of the body; and when we say that the mind is refreshed, it is really the body that we mean.

Even in sleep, when all the world is lost to our consciousness, we have not only reason to believe, but may rest perfectly assured, that the mind in itself is just as vigorous, and as actively employed, as it is during our most wakeful and best remembered moments. If we deny this, we deny that the mind is spiritual, and, by necessary consequence, we deny that it is immortal. For if the mind suffer during the sleep of a few hours, what shall we say of it during the sleep of death? There is a mystery, however, surrounding this part of the subject, which the eye of the flesh, and the understanding of the embodied spirit, cannot penetrate.

We have, however, in many things, very convincing evidence that the mind is in itself wholly unclogged by the frailty of the flesh, and that even in this world it can cast aside its earthly garment when it marches forth in the wonderful majesty of thought. The foot cannot convey us much more than four miles in an hour of time, without experiencing fatigue, and soon requiring rest; but in less than the twinkling of an eye, or than the hand or the shadow can measure on the dial, the mind shall not only be, in thought, round and round the world, but at every planet in the solar system, and far beyond all mensuration, into the depths of space and back again. So also in respect of time: the body must abide the lapse of its days and its hours, and can see and perceive nothing but what those days and those hours bring forth; but the mind can in an instant—a moment too brief for any measurement—glance back to before the world was created, and forward to that awful period, when time shall be no more. Many other instances might be advanced in illustration of the mind's independence of the material creation, and elevation above it; but the few that have been mentioned are of themselves sufficient to show that that breath of life which the Almighty Creator breathed into the nostrils of man, is something of finer nature and more permanent duration than any or than all that is to be found in the material world.

CHAPTER III.

ON THE PRETERNATURAL STATE OF THE HUMAN BODY.

1. What the preternatural State of the Body means.—2. The varietyof Diseases.—3. Reduced to Three Classes;—those of the Solids.—4. Those of the Fluids, particularly the Blood.—5. Those of the Feelings or Apprehensions.—6. The remote Causes of Diseases.—7. Of Fevers.—8. The Way to preserve Health.—9. Of Life and Death.

1. When the structure or disposition of the parts of the body is so disturbed and disordered that the natural operations are no longer performed, or not in the manner they ought, this is a preternatural state of the body, otherwise termed a disease.

2. There cannot but be a great variety of diseases, whether we consider the manner wherein that structure or disposition is disturbed, the part wherein each disease has its seat, or the various effects and circumstances of them. Some diseases only hurt the use of the parts; some wholly destroy it. Some affect this or that part; others the whole body. Some disorder the body, some the mind, and others both mind and body.

3. But they are all reducible to three classes—those of the solids, of the fluids, and of both. The solid parts may be bruised, wounded, swelled, or removed out of their natural place.

It is a wonderful provision which nature makes in one of the most dreadful calamities incident to the solids. When a bone is broken, let it only be replaced, and preserved in that situation, and nature does the rest, by supplying the divided parts with a callus.

This oozes out from the small arteries and bony fibres of the divided parts, in form of a jelly, and soon fills up the cavities between them. It soon grows cartilaginous, afterwards bony, and joins the fractured parts so firmly, that the bone will be more easily broken in any other part than in that.

A callus of a different kind is formed on our hands and feet. This is composed of several layers of particles, loosely connected. These, if steeped in fair water, easily separate, and then are found, if viewed through a microscope, to be all of one shape, resembling that of a weaver's shuttle, broad in the middle and pointed at each end. Being steeped again, they divide into a great number of smaller particles, all of the same figure with the first.

The thickness of the skin in the hands of those who labour hard is wholly owing to vast numbers of these particles, which combine together, but so loosely that they are easily separated on moistening. That thick skin is composed of several layers of different thickness, which have been added from time to time, each of which layers is only a congeries of almost an infinity of these particles.

But people who labour ever so hard will have little callus on their hands if they wash them often. The washing of the hands daily rubs off a great quantity of these scales; indeed it is surprising to see how large a quantity of them is daily thrown off from our hands and feet, though from no other part of the body. We may learn from this the great bounty of nature, in so carefully supplying the parts designed for walking or labour with an additional matter for their defence, which is not in any other part of the body.

4. The diseases of the fluids lie chiefly in the blood, when it is either too thick and sizy, whereby its motion becomes too languid and slow, whence spring the diseases owing to obstruction, or too thin. From the former cause arise leprosies, scirrhuses, lethargies, melancholy, hysteric affections, and if at the same time it abound in acid salts, the sharp points of these tear the tender fibres, and occasion the scurvy, king's evil, consumption, with a whole train of painful distempers. Fevers frequently arise from the too great thinness of the blood.

The plague is not an European disease: it is properly a disease of Asia, where it is epidemical, and is never known elsewhere but by importation from thence. The small-pox also is an exotic disease, and was not known in Europe, or even Asia Minor, till a spice trade was opened by the later princes of Egypt to the remotest part of the East Indies. Thence it originally came, and there it rages at this day.

5. As the disease and the decay of the body through which alone the operations of the mind are made known to others, very generally if not always occasion a weakness, and often a derangement, in the apparent state of the mind though we know, from its very nature, the mind itself can suffer no disease, no decay, and no derangement; so, on the other hand, the affections of the mind are often the causes of real or imaginary diseases in the body.

The mind can not only think of that which is past, and anticipate that which has not yet happened, but it can entertain thoughts of that which never did and indeed which never can happen. In this way the mind may occasion a great deal of uneasiness to the body,—may bring on many real diseases or actually bring it to the dust.

There are certain states of the digestive organs, known by the name of *dyspepsia*, or *hypochondriasis*, in which, though the sufferer feels himself ill at ease, he is unable to point to any part as being particularly diseased, or to say positively what is the matter. But though the mind is unable to know the nature or to fix the situation of those maladies, it is not the less sensible of their existence, and, being so sensible, it casts about, as is the case in uncertainty and hesitation on all other matters, in order to find something on which its thoughts may rest; and, as is the case whenever we are in absolute ignorance, there is but one right and all else wrong, the probability is, that the afflicted mind shall fix on anything rather than the true cause of the body's derangement. Hence arise those singular beliefs of imaginary maladies with which persons in this unhappy state fancy themselves to be afflicted. There have been instances in which such persons have imagined the whole body, or part of the body, to be turned into glass, or some other brittle substance, of the breaking of which they were constantly in fear, and to guard against which breaking they took the most ludicrous precautions. Those fancies, though in themselves ludicrous, are, however, by no means subjects of laughter, because the unhappy patient feels greater and more hopeless distress than if his body were afflicted with a known and even mortal disease. Such is the torment of the mind when the body informs it of a diseased state, without conveying any knowledge of what that state is.

There are also many maladies not very different from those, which arise from mental affliction alone,—from strong passions, or from gloomy trains of thought, when there is no diseased state of any function of the body to give rise to them. In many of those cases where diseases are considered to be infectious as regards the body, there is not the least doubt that the infection is wholly of the thought and the mind; and such appears to be the strength of this mental infection, that it very often brings the real disease upon the body, in its most hopeless and deadly form. This subject of infection, as affecting the physical condition of the body, is altogether a very mysterious one. It is not easy to suppose how the body can be inoculated with disease except by the direct application of diseased matter to it; and the atmosphere has such a power of scattering pestilent matters of all kinds so thinly through its mass, that we can imagine few instances in which they can be physically injurious beyond even a moderate distance. Thus arsenic, in any quantity, in an apothecary's drawer, never hurts those who live in the next house, or even those who serve in the shop; and the exhalation of a fen, which breeds ague or other diseases to those who inhabit low down on its border, is perfectly harmless to the inhabitants of a hill in the close vicinity. This is well exemplified in the island of Java; for while in the town of Batavia the night air is death, especially to strangers, one immediately from Europe, even though of weakly constitution, can sleep with perfect impunity on the neighbouring heights, which the pestilent vapour never reaches, or reaches in so small a quantity as to be harmless. So also in that part of Italy which is afflicted with the pestilent *malaria*, the healthy country is almost as finely divided from the unhealthy one, as if a mere line were drawn between them. This is, however, a subject of extreme difficulty, and one which is not yet brought within the limits of well understood philosophy.

6. Such are the proximate causes of diseases. As to the remote, the chief are these. 1. Intemperance in meat or drink, either with regard to the quantity or quality. 2. Want of exercise, or excess therein. 3. Immoderate sleep or watching. 4. Unwholesome air. 5. The diminution of some natural evacuation. 6. Irregular passions. All or any of these affect the temperature and motion of the blood and spirits.

7. But it can scarcely be conceived, after all that has been said and wrote, on almost every subject, how very little is known to this day concerning the causes of diseases. In most cases the most skilful physicians acknowledge they have nothing but conjectures to offer. We may give a specimen with regard to fevers, the most common of all distempers. These are of various kinds: at present we will speak of intermitting fevers only. Most of these agree in the following symptoms. During the approach of the fit, cold and shivering seize the body, with a small and low pulse. Heat succeeds with a quick, strong, hard pulse, followed by sweat and softer pulse. These fits return at stated times.

It is supposed, that these changes in the blood arise from some foreign matter mixed with it, which it cannot readily assimilate, and which therefore must in some measure hinder its motion: perhaps because the particles of it are too large, too long, or branching out. When the circulation is hindered or retarded chilliness naturally follows. And if these particles sticking in the finer passages are pressed on by the affluent blood, this will occasion both a shock and tremour of the muscles, and make the pulse more weak and slow. But when they are at length broken and comminuted by the continued afflux of the blood, it will flow more violently, and of course occasion heat, which driving the blood to the surface of the body, many of its thinner particles will burst through the pores, in the form of sweat. As to the fevers returning at stated times, it is supposed, the peccant matter is generated from time to time, and mingled with the blood afresh; whence the same symptoms of course return, and that with more or less violence, as more or less of that matter is generated. And as this is done more swiftly or slowly, the fever returns in one, two, or three days. But all this is mere conjecture. It may be so; and it may not. So that though we may guess much, we know nothing about it.

8. It is sufficient for us to know how we may avoid diseases, whether we can account for them or not. To this end, we should avoid whatever in meat, drink, motion, or rest, is likely to produce any considerable change in the blood. The body likewise should be as far as possible accustomed to bear some change of food, air, and other externals, that if we should at any time be constrained to

make such a change, no ill consequence may ensue. But no precise rule can be laid down, which will suit all constitutions. Every man must consult his own reason and experience, and carefully follow them.

As there are imaginary diseases, that is, diseases felt by the mind, though not actually afflicting the body; and as real diseases of the mind may be brought on by mental causes, so there are imaginary remedies. As the whole matter is imaginary, it is impossible to reduce those cures to anything like reason and system; and hence they open a wide field for impostors to practise upon the credulity of those who are afflicted by them. Nor is it easy to say how many pretenders have arisen to affluence, or how much the more sober and rational part of the healing art has been injured by those means.

9. As long as the soul and body are united, a man is said to be alive. But it is extremely difficult to determine the precise time at which life ceases, or what that is which is absolutely necessary to the continuance of it. Is respiration? But when this is entirely ceased, as is the case in a person strangled, blow strongly into the lungs, and they play again; which shows he was not dead before. Is the beating of the heart?—But when this also is ceased, in the forementioned case, take the same method, and when the lungs begin to play, the heart begins to beat anew. Is the circulation of the blood?—But persons drowned, who have been so long under water as to have no pulse remaining in any artery, and consequently no circulation, have recovered by the use of proper means, and lived many years after. Is the fluidity of the

blood? Nay, but it is a common thing in Sweden, to recover to life one who has been twenty-four hours under water; and who not only has no pulse, but is as stiff all over as any dead corpse can be. What then is Death? Undoubtedly it is the separation of the soul and body. But there are many cases wherein none but God can tell the moment wherein they separate.

Many who seem to be dead, may be recovered. ——A person suffocated by the steam of coals, set on fire in the pit, fell down as dead. He lay between half an hour and three-quarters, and was then drawn up, his eyes staring, his mouth gaping, his skin cold; not the least breathing being perceivable, nor the least pulse either in his heart or arteries.

A surgeon applied his mouth to that of the patient, and by blowing strongly, holding the nostrils at the same time, raised the chest by his breath. Immediately he felt six or seven quick beats of the heart; the lungs began to play, and soon after the pulse was felt in the arteries. He then opened a vein, which at first bled drop by drop, but in a while bled freely. Meantime he caused him to be pulled and rubbed. In an hour he began to come to himself; in four hours walked home, and in four days returned to his work.

Wherever the solids are whole, and their tone unimpaired, where the juices are not corrupted, where there is the least remains of animal heat, it would be wrong not to try this experiment. This takes in a few diseases, and many accidents. Among the first are many that cause sudden deaths, as apoplexies and fits of various kinds. In many of these it might be of use to apply this method; and in various casualties, such as suffocations from the damps of mines and coal-pits, the condensed air of long-unopened wells, the noxious vapours of fermenting liquors received from a narrow vent, the steam of burning charcoal, arsenical effluvia, or those of sulphureous mineral acids. And perhaps those who seem to be struck dead by lightning, or any violent agitation of the passions, as joy, fear, anger, surprise, might frequently be recovered by this simple process.

The animal machine is like a clock: the wheels whereof may be in ever so good order, the mechanism complete in every part, and wound up to the full pitch; yet without some impulse communicated to the pendulum, the whole continues motionless.

Thus in these accidents the solids are whole and elastic, and the juices no otherwise vitiated than by a short stagnation, from the quiescence of that moving something which enables matter in animated bodies to overcome the resistance of the medium it acts in. Inflating the lungs, and thus communicating motion to the heart, like giving the first vibration to a pendulum, enables this something to resume the government of the fabric, and actuate its organs afresh. It has been suggested that a pair of bellows might be applied, better than a man's mouth. But, 1: Bellows may not be at hand; 2. The lungs of one man may safely bear as great a force as the lungs of another can exert, which by the bellows cannot always be determined; 3. The warmth and moisture of the breath may likewise be of use.

But what is properly a natural death? From the very birth, every vessel in the human body grows stiffer and stiffer, by the adhesion of more and more earthy particles to its inner surface. Not only solid food supplies it with these, but every fluid that circulates through it. Hereby more and more of the small vessels are so filled up as to be no longer pervious. In proportion, the coats of the larger vessels grow harder, and their cavities narrower: hence the dryness and stiffness of all the parts which are observable in old age. By this means more and more of the vessels are destroyed, the finer fluids secerned in less quantity, the concoctions weakened, and the reparation of the decayed and injured parts prevented, so that only the coarser juices continue to run slowly through the larger vessels. Soon these also not only become narrow, but stiff, bony, and unelastic, till even the great artery, having lost its spring, can propel the blood no longer; and then follows death by old age, which is a purely natural death. But this is a very rare case: it is seldom life is so long protracted, the lamp of life being easily blown out when it burns with so feeble a flame. So that the age of man seldom exceeds threescore years and ten, before dust returns to dust.

The term of life can be prolonged but a very little time by any art we can use. A few only have lived beyond the ordinary duration of human existence, such as Parr and Jenkins; yet these men used no peculiar arts to prolong life. On the contrary, they were peasants, accustomed to the greatest fatigues, and who had no settled rules. Indeed, if we consider that the European, the Negro, the Chinese, and the American, the civilised man and the savage, the rich and the poor, the inhabitant of the city and of the country, though all so different in other respects, are yet entirely similar in the period allotted them for living; if we consider that neither the difference of race, of climate, of nourishment, of convenience, or of soil, makes any difference in the term of life; if we consider that those men who live upon raw flesh, or dried fishes, upon sago or rice, upon cassava or upon roots, nevertheless live as long as those who are fed upon bread and meat, we shall readily acknowledge that the duration of life depends neither upon habit, customs, nor the quantity of food, and that nothing can change the laws of that mechanism which regulates the number of our years.

If there be any difference in the different periods of man's existence, it ought principally to be ascribed to the quality of the air. It has been observed, that in elevated situations there have been found more old people than in those that were low. The mountains of Scotland, Wales, Auvergne, and Switzerland, have furnished more instances of extreme old age than the plains of Holland, Flanders, Germany, or Poland; but, in general, the duration of life is nearly the same in most countries. Man, if not cut off by accidental diseases, is generally found to live ninety or a hundred years. Our ancestors did not live beyond that date, and, since the time of David, this term has made but little alteration.

If we be asked how, in the beginning, men lived so much longer than at present, and by what means their lives were extended to nine hundred and thirty, or even nine hundred and sixty years, it may be answered, that the productions of the earth, upon which they fed, might be of a different nature at that time from what they are at present. But perhaps it is better to say that the term was abridged by divine command, in order to keep the earth from being overstocked with human inhabitants; since, if every person now were to live and generate for nine hundred years, mankind would be increased to such a degree that there would be no room for subsistence, so that the plan of providence would be altered, which is seen not to produce life without producing a proper supply.

But to whatever extent life may be prolonged, or however some may have delayed the effects of age, death is the certain goal to which all are hastening. All the causes of decay which have been mentioned contribute to bring on this dreaded dissolution. However, nature approaches to this awful period by slow and imperceptible degrees. Life is consuming day after day, and some one of our faculties, or vital principles, is every hour dying before the rest, so that death is only the last shade in the picture; and it is probable that man suffers a greater change in going from youth to age than from age into the grave. When we first begin to live, our lives may scarcely be said to be our own: as the child grows, life increases in the same proportion, and is at its height in the prime of manhood. But as soon as the body begins to decrease, life decreases also; for as the human frame diminishes, and its juices circulate in smaller quantity, life diminishes and circulates with less vigour, so that as we begin to live by degrees, we begin to die in the same manner.

Why then should we fear death if our lives have been such as not to make eternity dreadful? Why should we fear that moment which is prepared by a thousand other moments of the same kind, the first pangs of sickness being probably greater than the last struggles of departure. Death, in most persons, is as calmly endured as the disorder that brings it on. If we inquire from those whose business it is to attend the sick and the dying, we shall find that, except in a very few acute cases, where the patient dies in agonies, the greatest number die quietly, and seemingly without pain. And even the agonies of the former rather terrify the spectators than torment the patient; for how many have we not seen, who have been accidentally relieved from this extremity, and yet had no memory of what they then endured? In fact, they had ceased to live, during that time when they ceased to have sensation; and their pains were only those of which they had an idea.

The greatest number of mankind die therefore without sensation; and of those few that still preserve their faculties to the last moment, there is scarce one that does not also preserve the hopes of still outliving his disorder. Nature, for the happiness of man, has rendered this sentiment stronger than his reason. A person dying of an incurable disorder, which he must know to be so, by frequent examples of his case; which he perceives to be so, by the inquietude of all around him, by the tears of his friends, and the departure, or the face of the physician, is, nevertheless, still in hopes of getting over it. His interest is so great, that he only attends to his own representations; the judgment of others is considered as a hasty conclusion; and while death every moment makes new inroads upon his constitution, and destroys life in some part, hope still seems to escape the universal ruin, and is the last that submits to the blow.

Death, therefore, is not the terrible thing which we suppose it to be. It is a spectre which frights us at a distance, but which disappears when we come to approach it more closely. Our ideas of its terrors are conceived in prejudice, and dressed up by fancy; we regard it not only as the greatest misfortune, but as also an evil accompanied with the most excruciating tortures: we have even increased our apprehensions, by reasoning on the extent of our sufferings. It must be dreadful, say some, since it is sufficient to separate the soul from the body; it must be long, since our sufferings are proportioned to the succession of our ideas; and these being painful, must succeed each other with extreme rapidity. In this manner false philosophy labours to augment the miseries of our nature, and to aggravate that period which nature has kindly covered with insensibility. Neither the mind nor the body can suffer these calamities; the mind is at that time mostly without ideas, and the body too much enfeebled to be capable of perceiving its pain. A very acute pain produces either death or fainting, which is a state similar to death: the body can suffer but to a certain degree; if the torture becomes excessive it destroys itself, and the mind ceases to perceive when the body can no longer endure.

In this manner excessive pain admits of no reflection; and wherever there are any signs of it, we may be sure that the sufferings of the patient are no greater than what we ourselves may have remembered to endure.

But, in the article of death, we have many instances in which the dying person has shown that every reflection that pre-supposes an absence of great pain, and, consequently, that pang which ends life, cannot even be so great as those which have preceded. Thus, when Charles XII. was shot at the siege of Frederickshall, he was seen to clap his hand on the hilt of his sword; and although the blow was great enough to terminate one of the boldest and bravest lives in the world, yet it was not painful enough to destroy reflection. He perceived himself attacked, he reflected that he ought to defend himself, and his body obeyed the impulse of his mind, even in the last extremity. Thus it is the prejudice of persons in health, and not the body in pain, that makes us suffer from the approach of death: we have all our lives contracted a habit of making out excessive pleasures and pains; and nothing but repeated experience shows us, how seldom the one can be suffered or the other enjoyed to the utmost.

If there be anything necessary to confirm what we have said concerning the gradual cessation of life, or the insensible approaches of our end, nothing can more effectually prove it, than the uncertainty of the signs of death. If we consult what Winslow or Brubier have said upon this subject, we shall be convinced, that between life and death, the shade is so very undistinguishable, that even all the powers of art can scarcely determine where the one ends and the other begins. The colour of the visage, the warmth of the body, the suppleness of the joints, are but uncertain signs of life still subsisting; while, on the contrary, the paleness of the complexion, the coldness of the body, the stiffness of the extremities, the cessation of all motion, and the total insensibility of the parts, are but uncertain marks of death begun. In the same manner also, with regard to the pulse and the breathing: these motions are often so kept under, that it is impossible to perceive them. By approaching a looking-glass to the mouth of the person supposed to be dead, people often expect to find whether he breathes or not. But this is a very uncertain experiment. The glass is frequently sullied by the vapour of the dead man's body; and often the person is still alive, although the glass is no way tarnished. In the same manner, neither burning, nor scarifying, neither noises in the ears, nor pungent spirits applied to the nostrils, give certain signs of the discontinuance of life; and there are many instances of persons who have endured them all, and afterwards recovered, without any external assistance, to the astonishment of the spectators. How careful therefore should we be, before we commit those who are dearest to us to the grave, to be well assured of their departure. Experience, justice, humanity, all persuade us not to hasten the funerals of our friends, but to keep their bodies unburied until we have certain signs of their real decease.

Indeed, soon after the creation, when the earth was to be peopled by one man and one woman, the wise providence of God prolonged the life of man to above 900 years. After the flood, when there were three men to people the earth, their age was cut shorter. And none of these patriarchs, except Shem attained to 500 years. In the next century none reached 240. In the third, none but Terah lived 200: men being then so increased, that they built cities and divided into different nations. As their number increased the length of their lives diminished, until about the time of Moses it was reduced to 70 or 80 years, where it stands at this day. This is a good medium, so that the earth is neither over-stocked nor kept too thin of inhbitants. If men were to live now to Methuselah's age, of 969 years, or only to Abraham's of 175, the earth would be over-peopled. If, on the contrary, the age of man was limited like that of divers other animals, to 10, 20, or 30 years, it would not be peopled enough. But at the present rate the balance is nearly even, and life and death keep on an equal pace.

This is highly remarkable, that, wherever any account has been taken, there is a certain rate and proportion in the propagation of mankind. Such a number marry, and so many are born, in proportion to the number of persons in every town or nation. And as to births, two things are very observable: one, the proportion of males and females, fourteen males to thirteen females, which is exactly agreeable to all the bills of mortality: and this surplusage of males allows one man to one woman, notwithstanding the casualties to which men are exposed above women. The other is, that a few more are born than appear to die in any place. This is an admirable provision for extraordinary emergencies, to supply unhealthy places, to make up the ravages of epidemic distempers, and the depredations of war; and to afford a sufficient number for colonies in the yet unpeopled parts of the earth. On the other hand, those extraordinary expenses are not only a just punishment of sin, but also a wise means to keep the balance of mankind even. So one would be ready to conclude, by considering the Asiatic and other more fertile countries, where prodigious multitudes are swept away by wars and plagues, and still they remain full of people.

As to the length of life, it has been an ancient opinion, that men lived longer in cold countries than in hot. It does not appear, however, that upon men and races of men, who are habituated to them, different degrees of heat or climate are of much consequence. And this might be expected; because the natural temperature of the human body is nearly the same in all climates; and because in dry air the body can bear a temperature considerably higher than boiling water, while the Esquimaux feel no cold in their snow houses while the frost lasts, though they are uninhabitable after the thaw sets in. Hence, in the extremes of climate, it is moisture that does the injury, and not heat.

Before concluding this head, we may observe one more eminent instance of the divine wisdom, in the great variety throughout the world of men's faces, voices, and hand-writing. Had men's faces been cast in the same mould, their organs of speech given the same sound, and had the same structure of muscles and nerves given the hand the same direction in writing, what confusion, what numberless inconveniences must we have been exposed to? No security could have been to our persons, no certainty of our possessions. Our courts of justice abundantly testify the effects of mistaking men's faces or hand-writing. But this the wise Creator has taken care to prevent from being a general case. A man's face distinguishes him in the light, as his voice does in the dark; and his hand-writing can speak for him when absent, and secure his contracts to future generations.

Lastly, how admirably has God secured the execution of his original sentence upon every child of man, Dust thou art, and unto dust shalt thou return? From the moment we live, we prepare for death, by the adhesion of dust mixed with all our aliments, to our native dust; so that whatever we eat or drink to prolong life, must sap the foundation of it. Thus, in spite of all the wisdom of man, and all the precautions which can be used, every morsel we take poisons while it feeds, and brings us nearer to the dust from whence we came.

CHAPTER IV.

OF THE SOUL, AND OF THE ORIGIN OF MAN.

1. There is something in man which perceives the various Motions of the Body.—2. This Perception is sometimes continued and recalled.—3. We know some Things in a more sublime Manner.—4. There is something in us which has an Appetite to Sensible Things.—5. And another Appetite which is often contrary to this.—6. How Philosophers account for the Direction of our Bodily Motions.—7. For the External Senses.—8. The Imagination and Memory.—9. The Understanding, Will, and Affections.—10. This may be so, or may not.—11. Of the Immortality of the Soul.—12. Of the Union of the Soul and Body.—13. Reason cannot discover the Origin of Man.—14. The Scriptural Account of it.—15. Of the Production of the Soul.—16. Of the Generation of the Body.

1. Every one finds there is something in himself which perceives the motions raised in his body by outward objects; for when we see, hear,

taste, smell, or feel, while the objects affect our bodily organs, we find also various perceptions in our mind, according to the variety of those objects.

2. We observe, likewise, that after the objects are removed, those perceptions often continue, yea, and are variously mixed and compounded together, which we term imagination. And a long time after, when those objects are not only removed, but ever cease to exist, those perceptions return into our mind; and this we call memory.

3. And as we perceive these outward objects, so we know that we do perceive them. The mind can look inward upon itself, and reflect upon its own perceptions. Over and above this, we seem to find in ourselves a knowledge of things abstracted from matter. But the more we labour to penetrate into the nature of this divine principle, the more it seems to retire and withdraw itself from our most studious researches.

4. In like manner we find in ourselves various appetites for good things, and aversions to evil things; yea, the very involuntary motions of the body tend to avoid the evil and attain the good. And the things which are perceived by our senses, or represented by our imagination, so necessarily affect us, that we can by no means hinder ourselves from having an appetite for some, and an aversion to others.

5. Yet frequently a more hidden and sublime appetite exerts itself in our minds, one that checks, controls, and exercises authority over all the rest: for if we are convinced that the things which are pleasant are nevertheless hurtful, the appetite for them is overruled, and we find a desire, not to enjoy, but to avoid them.

6. In order to explain these things, philosophic men suppose that all the involuntary motions of the body are performed in a mechanical manner, by matter so and so modified, and that such effects spring of course from such causes, according to the stated laws of motion.

7. As to the senses, they suppose that when the organs of sense are struck by any of the bodies that surround us, and the motion caused thereby continued through the nerves to the brain, the soul residing there is suitably affected, God having so closely connected the soul and the body, that on certain motions of the body (if conveyed to the brain by means of the nerves), certain perceptions of the mind always follow; as, on the other hand, on certain perceptions of the mind, certain bodily motions follow.

8. They suppose, if these motions, which are by the nerves communicated to the brain, continue there after the objects are removed, the perception of these is imagination, which, if it occurs after it has ceased, is thenstyled memory. Others suppose that imagination results from the motion of the animal spirits, through those traces which were made in the brain while the outward objects were present; and memory, from the spirits moving through them afresh, after some intermission.

9. Once more. They suppose there are two faculties in the soul—one that is passive, the understanding, by which it perceives all the motions of the body, and knows and reflects on its own operation; the other active, the will, by which we incline to good and are averse to evil. the affections are only the will exerting itself variously on various objects.

10. To speek freely upon the matter, I know the body of man is contrived with such exquisite wisdom, that he is able, by means of the organs of sense, to perceive outward objects, to continue those perceptions, to recal them after they are gone, and, by a reflex act, to know what passes in his mind or body. But I know not how to account for any of these things.

11. That the soul is immaterial is clear from hence, that it is a thinking substance. If it be said, "God cannot endue matter with a faculty of thinking," we answer, no otherwise than he can endue a spirit with solidity and extension; that is he can change spirit into matter, and he can change matter into spirit. But even the Almighty cannot make it think while it remains matter, because this implies a contradiction.

12. The union of the soul and body is another of those things which human understanding cannot comprehend. That body and spirit cannot be implicated or twisted together like two bodily substances we know; but how two substances of so widely different natures can be joined at all, we know not. All we can tell is this: God has ordered that certain perceptions in the soul should constantly follow certain motions of the body, and certain motions of the body such perceptions in the soul.

13. How mankind began, is another point which is too hard for our reason to determine. That men always existed is no way probable, were it only on this account, the late invention of arts. For since it appears at what time the most necessary arts were invented, we cannot reasonably suppose that men began to exist long before

that period, seeing, if they had always existed, no reason can be given why these and many more arts were not invented long before. And yet the accounts given of the origin of mankind, by the wisest of the heathen philosophers, are so above measure ridiculous, that they serve as a melancholy proof of the weakness of barely natural reason.

14. The scriptural account is this. God made the body of man out of the earth, and breathed into him the breath of life—not only an animal life, but a spiritual principle, created to live for ever. Even his body was then perfect in its kind, neither liable to death nor pain; but what the difference was between the original and the present body, we cannot determine.

But to form it even as it is now, no less than a divine power was requisite: no less could temper material elements in so exact a proportion, and then frame so many different parts, of so various figure, texture, and magnitude. God alone was able to form the original fibres, to weave those fibres into hollow tubes, to dispose these tubes, filled with their several fluids, and variously interwoven with each other into different organs; and of those organs connected together in a continued series and due situation, to finish so complicated and wonderful a machine as the human body.

15. Nothing was wanting now but that the immortal spirit should be sent into its habitation, to bear the image of its Creator, and enjcy his glory. But the manner wherein this was done we cannot tell; this knowledge is too wonderful for us; and it is no use to indulge mere conjecture where knowledge is unattainable.

16. Even the present production of the body by

generation is what no man can fully explain; but this we know: that in man, and every animal resembling man, the connexion of two parents is necessary to the production of the young. As far as this is open to observation, it needs not be described; and beyond that, all else is mystery. We can, it is true, see the effects at different stages up to the perfection of the fœtus matured and ready for birth, but the causes are beyond our knowledge: we know what happens, but how or why it happens is what we cannot know.

On this, as on all other mysterious subjects, many visionary theories have been advanced. According to some of these, the new beings are animalculi in the male fluid; and, according to others, the germs of all after generations are contained in the germ as it exists in the ovary of the female. The first of these is a groundless fallacy, because it is known that conception sometimes (and probably most frequently) takes place under circumstances which preclude all possibility of the male fluid in substance coming in any way in contact with what may be considered as the germ in the female. The effect of the male is thus an emanation, and nothing more; and it is vain to attempt tracing the influence of the one sex upon the other to anything like the contact of material parts which are to form the new being. Thus the beginning of life is as much a mystery as life itself after it gives motion to the body. The first visible sign that appears (which is all the beginning we can know) is increased vascularity in the uterus, or womb, and along with this an augmentation of its bulk, and a new secretion within its cavity. The cervix uteri, or horn of the womb, is filled with inorganic jelly, while the rest of it receives an internal coating, consisting partly of lymph and partly of vessels. This coating of the cavity of the uterus is called membrana decidua, that is, "the membrane which parts or falls off," for a reason which will be explained.

While there is thus a receptacle, or habitation preparing for the embryo child, that embryo is preparing for its habitation. The embryo, or ovum, first appears in the ovarium. This, like the womb, becomes more vascular, and a small vesicle makes its appearance. The external covering of the ovarium appears to be absorbed, and the fimbriated or fringed extremity of the Fallopian tube embraces it more firmly than at other times. This tube receives the vesicle, which is the embryo, and conveys it to the uterus. That part of the ovarium from which the embryo has been separated undergoes a peculiar change, becoming what is called a corpus luteum, which shows that conception has taken place, but which in itself is to be fertile no more. It is probable, that, in many cases of impregnation, more than one vesicle is excited, and sometimes more than once descends into the uterus and becomes fertile; but in the majority of cases, one only is fertile, and the others are abortive and wither away. It is probable that the places of these become infertile, as well as those from which an embryo descends into the Fallopian tube: and the barrenness of females of abandoned character gives some countenance to this; but the point is obscure.

The ovum or embryo, from the first time that it can be observed, consists of two vesicles, the one within the other. The inner one contains a little colourless liquid, and the very minute embryo, and the space between the two, are filled with jelly bearing some resemblance to the white of an egg, or the vitreous humour of the eye. They are connected only at one spot, and the inner is very small compared with the outer. The surface of the external one is covered with small vessels, which soon increase, and are known by the name of the spongy chorion, whilst the enlargement of the vesicle is the membranous chorion. The second vessel, or that within both, is called the amnion, and the fluid which it contains liquor amnii. There is at first a considerable distance between the chorion and amnion; but the latter increases in size, and the jelly between them disappears. The embryo is not actually within these membranes; but at the point where it is, they jointly form a sort of hollow tube, along which vessels run from the spongy chorion to the embryo, and others from the embryo to the chorion. This tube is the umbilical cord, which is attached to the navel of the fœtus after it is developed.

The embryo does not fall loosely into the womb, but attaches itself to the decidua, and a union of the vessels of the two takes place. The two increase together, until the embryo and its membranes fill the cavity of the uterus.

The vessels which pass from the embryo and the decidua jointly, in time form a thick vascular cake, called the placenta. This placenta consists of two distinct parts, one of which is formed from the womb of the mother, and the other from the embryo, and the separation of these appears to be complete. All on the uterine side of this wonderful partition, is the old life of the mother; and all on the other side, is the young life of the child. That the child is in some way nourished through this partition is most likely; but it is not nourished by the blood of the mother in substance. After the child quickens into life, there is neither the same pulsation nor the same blood on the two sides of this partition. The pulse of the child, in all cases, beats much faster than that of the mother; so that, by means of the stethoscope, an instrument which tells the internal pulsation, the existence and the life of a child in the womb can be readily ascertained.

One other proof that there is not the same blood and the same life, even in the maternal part of the placenta and in the child, is observed from the fact, that either of the two may die, and the mother remain alive; or the child may even decay in the womb, without serious injury to the mother.

This perfect union and perfect separation of the mother and the child in the womb, at one and the same time, is perhaps one of the most wonderful things in the whole physiology of the human race; but nevertheless it is perfectly true. The blood which comes from the mother to the maternal side of the septum, or partition of the placenta, is arterial blood—blood which has undergone the renovating influence of the air in the lungs of the mother. It is therefore perfectly assimilated, and needs no action of breathing in the child. That which is returned to the fœtal side of the placenta is venous blood, which has performed its function on the child, and is no longer fit for the purposes of life; but how the one finds its way through the partition from the mother to the child, or the other its way back again from the child to the mother, are mysteries above our understanding.

There is one thing, however, upon which they throw a little light: the supply which the mother furnishes to the child in the womb is at once fit for the purposes of life in that child, without any such operation as the chyle must undergo after a human being begins to feed by the mouth; and this renders it highly probable that one use of the process of respiration is to complete the assimilation of the chyle which has mingled with the blood in its progress to the lungs, and make it unfit for the purposes of life.

This is a part of the philosophy of man upon which much might be written; but after we had wearied ourselves with a multitude of words, it would remain as much a mystery as ever. The doings of our Almighty Father are truly beyond all admiration, and they are not more so than in the origin of the human body, even in the way of ordinary generation.

When, and in what manner, the wonderful union between the mortal body and the immortal soul takes place, has often been the subject of conjecture; but all conjecture respecting it is, from the very nature of the case, perfectly futile, and can lead to nothing but mistakes. We cannot connect the date of this union with the commencement of any of the merely animal functions, as with circulation, with respiration, or with sensation; for these belong to the animal body only, as they show themselves in all animals. Hence the old dogma in medical jurisprudence, that the destruction of the fœtus becomes murder only after it is quickened, that is, after the pulse has begun to beat, ought to be expunged from the statute book, as absurd in theory, and as practically putting some of the most degrading crimes without the pale of the law. Of the spiritual part we can know no more than is declared of our common parent: "The Lord God breathed into his nostrils the breath of life, and man became a living soul."

PART THE SECOND.

THE LOWER ANIMALS.

CHAPTER I.

ANIMALS, AS DISTINGUISHED FROM MAN AND FROM EACH OTHER.

1. Relation of Man in Nature.—2. Man as distinguished from the Animals.—3. Reason and Instinct.—4. Organisations adapted to Reason and to Instinct.—5. Use of arrangements.—6. General Divisions of Animals; Vertebrated Animals.—7. Molluscous Animals.—8. Articulated Animals.—9. Radiated Animals.—10. Two Systems in Animals.—11. System of Growth.—12. System of Sensation.

1. We have taken a brief survey of the structure of man, the lord of the nether world, he whom it pleased the Almighty Creator to set in dominion over all the rest, and into whose nostrils alone, of all the living creatures which inhabit the earth the Almighty breathed the breath of life, and man became a living spirit and an heir of immortality, though connected with the flesh in all its frailties, during his sojourn here upon earth. In consequence of this mysterious union of mortal body with immortal spirit, man stands distinguished from every other creature; and the philosophy of his nature, when viewed in its full extent, is different in kind from that of theirs.

There is no doubt, that in as far as the mere material body is concerned, man is an animal, and subject to all the contingencies of animal life, just as the matter of which the living bodies of men and animals are composed is subject to all the laws of matter. But, in like manner as the life of an animal controls and triumphs over the properties of that dead matter of which its body is made up, so as to perform its animal motions and functions during the appointed period of its existence; even so the immortal spirit in man controls both the mere matter of the body and the animal life, and proves by so controlling them, that it is in itself something of higher origin and more pure and simple nature.

When we look around us in the world we see many proofs of this; the powers of the mind bear no proportion whatever to those of the body; for he who is feeble in frame, and incapable of using his hands and feet, is often stronger in wisdom and more unconquerable in spirit than the giants of the human race. That the mind does sympathize with the body in its sufferings cannot be denied; but even in the extreme of the body's weakness and wretchedness, on the bed of sickness or at the hour of dissolution, when the angel of death stands ready to dissolve the mysterious connection, and the body is to be consigned to its kindred dust to moulder there until the trumpet shall sound and the dead shall be raised,—even then, new hope can dawn upon the mind, and it can take up its song of triumph, "O death, where is thy sting? O grave, where is thy victory?"

2. In consequence of this compound nature of man, the actions of his body may be said to be

under two distinct species of government, even leaving out that gracious Providence by which all things are maintained, but which forms no part of creation or its philosophy. The first of these is a merely animal government, and refers to the growth, the nourishment, and the health of the body, and all those operations by which these are maintained; and which go on, not only without will or purpose on the part of man, but, generally speaking, without his knowledge. In as far as these go, man resembles the other animals; and his history forms part of their history; but here the correspondence between them stops.

The other part, and the one which is peculiar to man, is that of acting from knowledge and experience; reasoning of what shall happen, from what has happened, and by means of this experience increasing in wisdom as he increases in experience. This too, not in the individual alone, for the knowledge of man does not perish as the beasts perish, or as his own body becomes dust in the tomb; it remains as a heritage to future generations; and the means which man has invented of embodying this knowledge in words, printing it in books, and so treasuring it up for all generations, is one of the most striking and most delightful proofs which we have, that this mental portion of man, in the possession of which he stands alone, is the noblest part of his inheritance. When we think of this, and compare human schemes and their execution with the most extraordinary actions of the other animals, we find that there is a fundamental distinction between them. No matter what the animal might do: it may build with the industry of the beaver, or the apparent mathematical science of the bee, or it may perform many other operations with a certainty and perfection which no human art can reach; but still not one of its actions, be they what they may, is more wonderful than the fact of its growth, and the development of its several organs, or even the simple fact of its existence.

3. For the sake of distinction, it is usually said that man is, in all his voluntary actions, guided by reason; and that the other animals are guided by instinct. These words are not badly chosen. Reason means the comparison of one thing with another; and in its more general sense, as applicable to the thoughts and conduct of man, it means the comparison of that which he purposes to do, with that experience of the past, either felt in himself, or learned from others, which is to be his guide in the doing of it. From this short explanation it will be seen that reason implies in it all that is necessary for understanding that portion of man's conduct which depends on his mind; for the very fact of being able to compare his own purpose to-day, with his conduct on a previous day, leads at once to the same kind of comparison between himself and any other individual whose history he may know, at what time soever that individual may have lived. This is the foundation of progressive education, and the acquiring of knowledge from generation to generation; and as no other animal partakes even in the slightest degree of this faculty, a distinction of the clearest nature is thus established between man and every other mortal creature.

Nor must we, however ingenious any creature may appear in what it does, however tractable it may be to our training, or however it may display what we consider profound sagacity, in these cases, or in any of them, attribute even the slightest approach in kind to human reason; for the stamp of reason, the capacity of comparing, profiting by experience, and teaching one another so as to establish a growing stock of knowledge, is not in the slightest degree upon even the most apparently wise animal in existence.

Instinct, on the other hand, though possessed by man up to a certain point, is the proper badge and characteristic of the other animals. Instinct, taken in a general sense, means the capacity which is within, which borrows nothing from comparison and cannot profit by experience, but acts from the impulse of present objects on its organs of sense; alike indifferent to and ignorant of the past and the future.

As this instinct is all that the animal has to depend upon, we might naturally suppose that, within its sphere, it would be far more perfect than even the reason of man; because the judgment of man's reason partakes of the finite and fallible character of man's mind, whereas the instinct of the animal, is a part of its nature as it was created by God; and, therefore, it is as true to that nature, as corn is to its ear, or a plant to its flower.

But the very circumstances which thus tend to give to the instincts of the other animals, within their proper spheres, a degree of certainty and perfection which, from its very nature, the reason of man never can have, they are each limited within a very narrow compass as compared with the range that man is enabled to take in consequence of the possession of this reason, all liable to mistakes and errors though it be.

4. When we compare the structure and organisation of the human body with those of the bodies of other animals, we find the most convincing proofs of the distinction which has been noticed. The body of man may be said to be a sort of universal structure; and there is no one part of it, as obedient to the mind, which we can consider as more peculiarly fitted for one species of that action which it can perform than for another. This general adaptation of the body necessarily renders it less perfect for any one individual purpose, than if it were more limited in its applications; and hence we find that there is no single act of the body of man, considered as mere matter, in which he is not far surpassed by some other animal.

Nor is the adaptation general as to that which man may do, it is general also as to where he may do it. There is no animal which can bear such extremes of heat and cold, or of drought and moisture, as man can bear. No doubt, as the body is matter, and in so far under the laws of matter, it is differently affected by differences of situation and climate, so that the people who inhabit the warmth of the equatorial regions, those who inhabit the dreary cold of the polar zones, and those who enjoy the alternate seasons and temperate atmosphere of the middle latitudes, are all different from each other in appearance. Nor is this all: for even in the same country we find such differences between the inhabitants of different districts, as for instance those of the mountains and those of the plains—that if we are well acquainted with their general aspect, we can distinguish the one from the other, even when we meet with unknown individuals at a distance from their native places. But, making allowance for those adaptations to climate, it may be said that man can inhabit any portion of the earth's surface, while every other animal in a state of nature has a peculiar locality, in which alone it preserves its health and multiplies its numbers.

Thus, the lower animals are so much more under the control of local circumstances than man is, that their localities, their structure, and their habits are parts of the same history; the one of which throws light upon the other, and, therefore, the study of those animals is far more instructive, in as far as the philosophy of merely organised and animated matter is concerned, than the study of man himself, which is of a mixed nature; and the higher qualities of mind continually tend to draw our attention away from the more frail and humble properties of the body.

Thus, in endeavouring so to contemplate animated nature, as to see, to admire, and to adore the wisdom and goodness of the Creator in it, it is as well to leave man out of the connection. This being done, we are enabled to examine and arrange all the rest as one kingdom of nature; and our true wisdom consists in viewing the several members of this kingdom in their relations to each other, and to the circumstances under which they are usually seen.

5. The individuals, and even the kinds of animated beings are so numerous, that, if we were to attempt to acquire the knowledge of them by examining each individual singly, our labour would be

as vain as if we tried to count the sand on the sea shore. Therefore, we must have some means of arrangement,—dividing first into larger portions, and successively subdividing these, until we arrive at the individuals. This is what is called a system of animated nature; and the more recent systematic arrangements apply well both to the structure and the habits of the different animals, and thus convey far more knowledge in few words, than all the detached anecdotes of single animals, which were previously very improperly dignified with the name of natural history, but which had no more real pretension to the name, than the idle tales on the shelves of a library have to that of a philosophical history of man.

6. It required, of course, that much should be known respecting living creatures, both in their organisation and in their habits, before anything approaching to a good system could be formed. When we look at the whole of animated nature, and attend to the organisation or structure, we find two grand divisions or provinces, so distinct from each other that they form one step of a very natural arrangement. Between these the grand distinction is the possession or the non-possession of a backbone, or, as it is called, a vertebral column, from the fact of its being made up of a number of vertebra or distinct pieces, articulated or jointed to each other.

The possession of this bone is a very clear and distinct character, and brings within the division of which it is characteristic every animal which possesses it. But the character of the other class, or remaining part of living creatures, is by no means so distinct and satisfactory. We call them invertebrated, or backboneless; but as this name applies not to what the animal has, but to what it has not, no positive character can be founded upon it. Hence it becomes necessary again to divide this portion of animated nature, which is by far the most numerous portion; and here there are three remarkable divisions, each of which has a common character throughout all the species which it includes, though in other respects those species differ greatly from each other.

7. One division—and they in some respects approach the vertebrated animals, though they differ greatly from these in others—is called mollusca, or molluscous, that is soft animals. Snails, slugs, and all those curious shelled animals which inhabit the land, and more especially the sea, the shells of some of which are so beautiful, the bodies of others so wholesome as food, and the labours of others again so wonderful and well worthy of study, belong to the molluscous division of invertebrated animals. All those molluscous animals are entirely destitute of bones in the interior of their bodies; but many of them are, as has been said, furnished with shells for their protection. Some never quit their shells, as is the case with oysters; others again crawl along, carrying their shell or house on their back, as may be seen in the common snail which frequents gardens. There are still others which have a sort of shell embedded in the cloak, or thick membrane, which invests the upper part of the animal; and there are others which have no protection except this cloak. It is worthy of remark, as showing how well all the children of nature are provided for, that the naked slugs, in our gardens, can endure cold much better than the shelled snails.

8. A second division of invertebrated or back-boneless animals are called articulata—that is, articulated or jointed animals, the general character being that the body and the limbs are cased in an external covering which is more or less hard, serving them in place of internal bones, and being jointed whenever the habits of the animal requires that a particular portion of it should bend, or otherwise have motion.

The number of articulated animals is very great; the subdivisions of which they admit are numerous; and common language, as applied to them, is exceedingly inaccurate, not only in popular discourse but in very many of the popular books. Among them are included all those animals usually called insects. The house-fly, which attends man in all his migrations over the globe, but is rarely if ever seen in the wilderness; the bees which gather the honey; the butterflies which sport in the summer sun, and some of which are so bright in their colours that they resemble living gems on the wing; the moth which sports around the candle, and ultimately falls a sacrifice to his ignorance of its nature, thereby reproving man sharply for intermeddling with that which he does not understand; these, and countless thousands of others, which tenant the air, the earth, and the waters, and plant a colony in every tree, and often a multitude in a single leaf, belong to this division. So also do animals of very different natures and dispositions: the laborious spider, which weaves and repairs its web, the emblem at once of industry and patience; the crab, the lobster, the poisonous scorpion, and countless numbers more, are articulated or jointed animals; but their differences of structure and habits are so great that they require much subdivision, before we can apply as many characters equally to a number of them as will amount to useful knowledge.

9. The last division of invertebrated animals are called radiata—radiated or rayed animals, because the different parts of them appear to proceed from a centre, something in the same manner as the spokes proceed from the centre of a wheel, or as light beams all round from the flame of a candle or the body of the sun. There is something peculiar in the structure of this division of animals, which distinguishes them from all the rest. The others, whether they have bones or not, have generally the parts of their bodies arranged in what is usually termed a symmetrical form; that is, there is some way in which we could suppose the body to be divided into two parts, the one of which would be the counterpart of the other; that is, they would be alike in their form, only the one turned to the right hand and the other to the left, just as our own hands are alike in their form, but turned opposite ways. This is what is meant by a symmetrical animal; and the radiated animals have little or none of this symmetry. They appear to have a circular arrangement, and have no visible organs of sensation, though they unquestionably possess animal life. A common name given to them is zoophytes, that is animal plants; but the name is not altogether a correct one; because every animal is a plant in a certain sense of the word, while no animal is a plant in that proper signification of the term, according to which plant has the same meaning as vegetable.

10. Every animal, to which soever of these

divisions it may belong, and whether its organisation approaches that of the human body, or is apparently not very different in structure from a vegetable, consists of two systems, which, though they act in concert with each other in the economy of the animal, yet appear to be perfectly distinct in their natures. The one of these may perhaps be called the vegetating or growing system, and the other the animal system, or the one which is more peculiarly characteristic of this kingdom of beings.

The vegetable or growing system of an animal is, no doubt, different in the mode of its action from that of a plant; and this mode differs greatly in different animals. There is, however, nothing radical or essential in it, upon which the distinction between an animal or a plant can be clearly established. Both originate from germs which are transferred in the course of generation from parent to offspring, in unbroken succession; and there is no instance in which so great a deviation is made as that there is a change from species to species, either in plants or in animals, and far less need we look for any change from the one of these to the other; though upon the mysterious confine, where the characteristic system of the animal is but little developed, and therefore not very open to observation, it has sometime been unguardedly said that such changes may take place, and that the same identical portion of matter may (of itself!) become a plant under one set of circumstances, or an animal under another.

This is true in one respect, but to state it generally is unwise as well as untrue: for though a plant and an animal may be both capable of adding the very same kind of matter to their substance, in the way of nourishment; yet the germ must not only exist, but must be developed, and in an active state, before this can be done by either the one or the other.

In this we have a proof of the creation of every species of plant and animal, as an original work of the Almighty, allowed a certain range of deviation, so that it may in so far yield to circumstances and live—as is the case with every created thing, with the sun, the moon, the planets, and the earth itself, as well as with those lesser creatures which we observe upon the earth, but still fenced in with bounds which Almighty Wisdom has ordained it, and to be produced and preserved in that way which of His good pleasure he has appointed. This is a truth of which we ought never to loose sight when we study the works of creation; because it is the grand star which keeps us in the path of truth, when we endeavour to extend our inquiries and exercise our thoughts upon a subject so vast and so varied.

11. The vegetable or growing system of an animal may be regarded as including all that tends to the growth of the body to its proper dimensions, the preservation of it for its appointed time, and the continuation of the species. In the growth or nourishment, animals differ from vegetables in taking their food in some sort of local stomach, in which it is digested, and rendered fit for forming part of the materials of the body while increasing in size, or of repairing the waste after the growth has ceased. There are various ways in which this operation is performed. In all the vertebrated animals, there is some resemblance to the process of nutrition in man, as explained in the first part

of this volume, in which the nourishment goes first to the blood, and the whole body is supported by the circulation of that fluid.—But, in some of the invertebrated animals, as in the insects for instance, it does not appear that the nourishment goes to the blood in the first instance, at least wholly, but that it is conveyed from the digestive organs directly over all parts of the body. Yet in all cases, how different soever, there is some feeding, some keeping up of the system; and there is also an action of the atmosphere required, which bears some resemblance to the operation of breathing in man. In all animals, too, this operation appears to be attended with results very much resembling each other; for whether the breathing is by lungs as in vertebrated land animals, by gills as in fishes, or by any other apparatus, the oxygen of the breathed air is invariably changed into carbonic acid when it escapes from the breathing apparatus. But this breathing, though it may appear to be one of the most remarkable characteristics of an animal, is not a part of the truly animal system, but rather of the vegetable; and we find that the air is just as necessary for the growth and health of vegetables as for animals.

12. That system of functions in an animal which is peculiar to this kingdom of nature, and to it only, is what we may with propriety call the characteristic animal system, the external displays of which may be comprehended in the two expressions, sensation and voluntary motion. Some plants are endowed with an apparent species of sensation. Thus, for instance, the sensitive plant falls down when touched; and all plants which are placed in a dark apartment having only one light admitted,

approach that light. This latter propensity is so strong that there have been instances in which the stems of a potato, which had been left in a dark tower, have contrived to rise to the height of forty or fifty feet, in order to reach the only little hole by which light was admitted. These things however, are not sensation; and the motion of the plant toward the light in the one case, or away from the finger that touches it in the other, is no more voluntary motion than it is voluntary motion in a ripe fruit or a withered leaf to fall from a tree, or in the waters of the ocean to rise and fall in tides, obedient to the varying attractive influences of the sun and moon.

The brain and nerves are understood to be the original source of animal sensation, though the subject is of so delicate a nature that we can obtain no positive evidence respecting it. If, however, we are contented with analogy or comparison, we invariably find that the general sensation of animals, as well as their peculiar organs of sense, are very much in proportion as the brain and its nervous extensions are more or less developed; and hence the distinction between vertebrated animals which have the nervous system more perfect, and invertebrated animals which have it less so, is something more than a mere structural difference.

In the case of all animals, the muscular fibres are the organs of voluntary motion; and it is possible that they also are the means by which sensation is communicated; at all events, there appears to reside in the muscular fibres a more general sense than that which is restricted in its exercise to any particular organ. This general sense of the muscles is very nearly the same with what is commonly called the sense of feeling or the sense of touch; though the degree of this in any part of the body of an animal appears to depend very much upon the kind of covering with which that part is invested.

Though the sense of feeling, and perhaps all the senses, are ultimately referable to the muscles in some way or other, yet it appears to have its original situation in the skin of animals, which is traversed in all directions by nervous filaments; and those filaments, in parts which are peculiarly sentient, are spread out upon the external surface of the true skin in minute papillæ or knobs, which are, however, protected from the external air by a thin coating of the epidermis, or scarf skin. In most animals, heat and cold appear to affect this sense fully as much as anything else; and also those animals which are much exposed to changes of temperature are generally enveloped with a thick coating of hair or feathers, substances which, though generally sensitive to the touch, are bad conductors of heat and therefore the best protection against variable climates which can well be imagined. There is a remarkable provision of this kind in the hair of the human head. Many reasons leads us to conclude that the brain which is lodged in the cavity of the head, is the most important organ of the human body; and that it is the great development of the human brain and its nervous system, with the consequent perfection of all the senses as organs of intelligence, which renders the human body so well adapted for being the peculiar instrument or minister of the immortal spirit. Accordingly we find that the protection of this part of the body is not left entirely to the discretion of man, as it is in the other parts; but that it has a natural covering of hair, which hair is wonderfully adapted to the climate, being a protection against excessive heat in tropical countries, and a thatch against rain and snow in the extreme latitudes near the poles.

While an animal is alive and healthy, it is probable that the covering of its body, whatever that covering may be, partakes in the life of the animal, and to some extent at least in the sensibility or feeling. This probably extends to the greater number even of the shells of living animals, which are generally covered over with a thin membrane, which perishes when the animal dies. It appears also that the located senses of tasting and smelling, which are situated in the mouths and nostrils of animals, do not differ much, except in their being local, from that general sense to which we give the name of feeling. The eyes and ears, which according to our notions, are the most wonderful organs of sense, are differently modified. The eye is acted on by light, and by light only; and the degree of light which suits best for an eye, and also the structure of that eye as commanding a view, vary much in different animals; though in all they are equally well adapted to what may be regarded as the natural habits of the animal. It is very doubtful whether any eye except that of man has a perception of what we call beauty, either of form or of colour; because animals, even those which we consider the most sagacious, do not appear to be in the least affected by differences in this respect. Whether the sight of the eyes of all animals, or of any animal, extends so far into space as the sight of the human eye, we have no means of ascertaining: but it is certain that dogs and some other animals can extend their vision as far as the moon, because they howl and make a noise at the sight of that luminary. In many animals, the sense of hearing appears to be very perfect; and to apply not only to those sounds which more immediately concern them in their own economy, but even to the sound of words and to music. All animals which can be domesticated, can also be made to answer to their names, or come when called upon; and this is not confined to the more perfect animals, but is found in some of the cold-blooded species. That serpents can be charmed by particular sounds has been known from the time of the Psalmist, and it is yet practised in some of the eastern countries. There are instances too in which toads, which perhaps belong to the lowest order of reptiles, have been trained to come when called; and there is a story of a French captive in a dungeon, who had a pet spider that came readily to amuse him at his bidding.

How the sensation, on what sense soever it is produced, ultimately affects the will and the muscles of the animal, is a subject upon which we most probably must remain ignorant; for though we cannot positively deny any of the theories that have been advanced in explanation of it, we are just as unable to prove the truth of any one of them. In all cases, however, quick sensation is accompanied with a corresponding development of the brain and its nervous continuations; and from this we may conclude generally that there is some sort of connection between the nervous system and animal sensation and motion; or, in other words, that the brain is the characteristic organ of an animal, and that the animal is developed, or, as we usually term it, perfect, in proportion as the nervous system is perfect; but how that system acts, or can act, is beyond the ken of our philosophy.

In those animals which are destitute of local organs of sense, and have their whole sensation reduced to the general sense of feeling, there is no brain, properly so called, but the nervous mass is scattered through the substance; and when we come to the very lowest or least developed of these, we find the life so dispersed over their bodies, that if one of them is cut in pieces, and the pieces left in their proper element, each piece will in time become a perfect animal. Thus they can be multiplied by cuttings just as plants can be so multiplied, but still they evince the grand animal character of sensation; for though they should appear little else than a bit of tube, as is the case with the fresh-water hydra, still that tube has sensation, and writhes under injury in a manner which is never found in any plant, however developed or however curious.

CHAPTER II.

PRINCIPAL CLASSES OF VERTEBRATED ANIMALS.

1. Names and Distinctions of Classes.—2. Mammalia.—3. Birds.—4. Reptiles.—5. Fishes.—6. General Characters of Vertebrata.

1. VERTEBRATED animals, or those which have back-bones, are adapted to four distinct modes of life; and organised principally so as to suit

those modes, though some of them combine two or more. Those four modes of life, and their corresponding organisations, furnish us with a very ready and very distinct means of dividing vertebrated animals into four classes.

2. The first mode of life is walking, leaping, or running on the surface of the ground, to which may be added climbing trees, and occasionally digging or burrowing in the ground, for the purpose of making a habitation or hiding place. All vertebrated animals which are organised to this habit are provided with four feet, and accordingly, one of the popular names of them is quadrupeds, or four-footed animals; but the name is not a correct one, inasmuch as all animals which have four feet do not belong to this class. All of them, however, are warm-blooded; and the females bring forward their young either to full maturity, or for a certain period at least, in an internal uterus or womb; and they all without exception, suckle their young with milk, for a longer or shorter period, according to the habit; and for this reason they get the general name of MAMMALIA, that is, sucking animals, which character belongs to them, and to no others.

Those mammalia which do not bring forward their young in an internal uterus, until those young have arrived at maturity, are provided with a second kind of apparatus in which to carry them; and when in the more characteristic species the young are transferred into this second receptacle, which operation the mother performs with her mouth, they are very minute, and hardly any function of life is observable in them. Those animals are called marsupial animals, or MARSUPIALIA, from the marsupium, or pouch on the abdomen of the female, in which the young are placed when they leave the internal uterus, and in which also the teats, or mammary apparatus for nourishing the young ones, are situated.

These are very singular animals; and it is but lately that we were properly informed as to their habits. They are confined to peculiar localities, and by no means so generally distributed over the earth as the common mammalia. The most characteristic ones are natives of New Holland, or of the other Australian island, Van Diemen's Land; and with but few exceptions, and these probably all imported one time or other, the whole mammalia of that country are marsupial. A few also having this structure, though in a less perfect degree, are found in the south-east of Asia; and there is at least one or two in America; but none of these are so typical or striking in this curious character as some of the Australian species; of which the great kangaroo is the most typical, and the most celebrated, as it answers in some respects, in that country, to the sheep and cattle of other parts of the world.

Those marsupial animals cannot well be brought into the subdivisions of the common mammalia, because their habits vary much. Some of them are ferocious and blood thirsty; others are harmless, though capable of making a stout resistance when attacked; while others again are so gentle in their manners, that they scarcely resent the most cruel usage. The countries which these singular creatures inhabit, are as singular in some respects as the creatures themselves; and thus we find, even in them, unquestionable proofs of that wise purpose and exquisite skill of adaptation, which the Creator has written in colours so legible, in the volume of the whole book of creation.

Though the mammalia, generally speaking, inhabit the land, and though they all breathe the free air of the atmosphere, yet there are some of them which inhabit the waters, and lose many of the external characters of land mammalia. The chief of these are the CETACEÆ, or whale tribe, some of which are the largest of known animals, and they are all of considerable dimensions, the greater portion being inhabitants of the seas, and capable of very rapid motion through the water; but there are some which inhabit the fresh waters of warm latitudes, and graze the plants which grow in the shallows, or in the humid meadows on the banks. Many of these, indeed most of them, have partly the external form of fishes, and are sometimes called by that name; but they are all true mammalia, or warm-blooded animals, which bring forth their young alive, and suckle them with milk: the milk of the common whale, for instance, being of the consistency of cream, and very pleasant to the taste.

3. The second mode of life among vertebrated animals is, inhabiting the air, or rather the capacity of continuing supported in that fluid, above the surface of the earth, for a longer or shorter time, according to the organisation and the particular mode of life. The class of animals, of which this is the characteristic habit, are BIRDS: and though they are not the only animals which can make their way through the air, they have a peculiarity of form, and of feathered covering to their bodies, which nobody can mistake.

But still, though this is the general character of a bird, and one which cannot be mistaken, it does not thence follow that every bird shall necessarily have the power of flight. Every creature has its appointed place and use in creation, to which it is specially adapted by its organisation; and there is abundance of food for birds in situations where flight through the air would be quite superfluous. Now it is the beauty of creation, that, while there is no want in it, there is as little superfluity and waste; and herein we have a wonderful display of the superiority of God's working over the workings of man, even when man exerts his utmost skill and dexterity. Man's most perfect works are burdened and encumbered by unnecessary parts, which serve no other purpose than to hang as dead weights upon the rest, and to wear them out; whereas, in the productions of nature, in all that the Almighty has made, we find exactly that which is required of the very best form, and in the perfect measure; but we find nothing more—no supernumerary part which can become a burthen to the animal in the fulfilment of that purpose for which it is ordained. Hence, those birds which career over the margins of the vast and treeless deserts, where there is nothing to interrupt their march upon land, have not wings adapted for flight; but, on the contrary, have their feet approaching in form to those of the swift-running mammalia. So also, in some birds which rarely, if ever, leave the water, but can pursue their food in it from day to day, the wings are equally unfit for flight, and bear more resemblance to fins, which are the proper organs of swimming, than to those wings which are adapted for supporting their owner aloft in the air.

But whatever may be the kind of motion for which an animal of this class is best or principally adapted, it is still a true bird in its internal structure, and in all the more essential parts of its character. One of these is, that the young are produced from eggs. This is a very common mode of production. Certainly the mode among by far the greater number of living creatures, and perhaps the original germ or rudiment of every animal bears some resemblance to an egg, for some time of its existence, longer or shorter. But the egg of a bird is so peculiar that it cannot be mistaken for that of any other class. The nearest approach is in the eggs of some reptiles; but even there, both the internal contents and the external covering are different. The shell of the reptile's egg resembles parchment much more than that of any bird does; and it does not boil hard in the same manner, thus indicating that there is more of that matter, which, from the white of an egg, is termed albumen in the eggs of birds, and more of gelatine in those reptiles.

4. The third class of vertebrated animals, to which the name of REPTILES is given, do not so strictly belong to any particular situation, and therefore are not so uniform in their structure as the mammalia or the birds. Generally speaking, they are covered with naked skin or with scales; some are furnished with four feet, a few with two only; and there are others which are entirely destitute of feet. Though the name given to this class is reptiles, yet it is not a very correct one, inasmuch as it is not accurately descriptive of the whole class. Reptile means that which creeps or crawls; whereas some animals of this class can perform a species of flight, not by wings, properly so called, but by membranes, or thin expansions, bearing some resemblance to leather. Others, again, are

remarkable for the swiftness with which they can run; and there are not a few which regularly inhabit the water, and are expert swimmers. Many of the true serpents are destitute of feet; but then the motion of these is gliding or twining rather than crawling. The name, however, is a matter of small consequence if we understand how to apply it; because no word has any meaning except in the application. Of these reptiles some, as the turtle, lay attached eggs, resembling the eggs of birds; others lay eggs in attached masses, as the spawn of frogs, which bear some resemblance to the spawn of fishes; and there are others again which hatch their eggs internally, and bring forth their young alive. This is a curious class of animals; and there are many wonderful displays of purpose and adaptation in it. But we shall be able, with greater advantage, to notice some of these in a future chapter.

5. The fourth and last class of vertebrated animals are well defined, both in their locality, and in their form and structure. They are the FISHES, wholly inhabitants of the water, and, generally speaking, capable of breathing only in that element. They have but one motion, that of swimming, to which their whole structure is adapted. Many of them, indeed, can leap to a considerable distance out of the water; and some which have those fins that correspond to the fore legs of mammalia, or the wings of birds, very large, are capable of supporting themselves in the air for a little while, but they are quite helpless, and incapable of renewing their motion in that element; so that it is incorrect to call them flying fishes. The blood in these animals is still colder than in the

reptiles, and their organs of sensation are less developed; but still the adaptation of a goat to the rock, of a wild deer to the hill, or of an eagle to the sky, is not more perfect than the adaptation of a fish to the water. Fishes, like reptiles, are produced from eggs, which are often so exceedingly numerous, that there are several millions in one production; and, as is the case with reptiles, some of them deposit their eggs, and leave them to be hatched by the action of the elements, while others hatch them internally. Fishes are a silent class of animals; and because they remain chiefly under the water, they are not often seen; but their numbers are beyond all counting and all imagination, and the wonders of creative power are nowhere more strikingly displayed than in those mighty waters which form the principal abode of these animals.

6. Although these four great classes of the animal kingdom differ from each other in very well-marked characters; and though the smaller divisions which each class comprises, also differ greatly from each other; yet there is one general character that runs throughout the whole, and stamps the vertebrated animal as belonging to a higher order of created existence than the animal which has not this character.

In them all, the provision for the existence and safety of the nervous system—the brain and its spinal constitution, which we are to consider as the grand animal organ, the evidence of a superior degree of sensation, is the principal part, upon which, as a foundation, all the rest appears to be organised, and which is protected both from external injury, and from any violent concussion or compression to which it might be subjected in the proper action of the animal, by contrivances framed with the most matchless skill. In proportion, too, as any animal stands higher in the vertebrated grand division, has its nervous system more fully developed, and its animal faculties more acute, this important part is always the more securely protected in a case of bones, which are less liable to be broken or removed from their places than any others in the system.

This spinal column has the head articulated to one extremity; and as the head contains the greater portion of the nervous mass, it is naturally regarded as a most essential part of the animal. From the head the vertebral column passes down the middle of the back of the animal, covered more or less with the muscles or flesh, in proportion as it is to have more or less motion in the action of the animal; and in the greater number of animals it is prolonged backwards in an extremity, to which the name of a tail is given. On this backbone, as a foundation, the whole skeleton or system of bones in the animal is constructed; but in the construction there is a beautiful provision for the security of this bone and its important contents, against all jostling and concussion. The arms in man, the forelegs in the mammalia, the wings in birds, and also those limbs or organs of such reptiles and fishes as have them, which answer to the forelegs, are never jointed or articulated directly upon the spinal column. The bladebones are imbedded in the flesh; so that whatever concussion the fore extremities of the animal may sustain, the force of it is taken off by the yielding nature of this flesh, and it does not affect the spine, at least to an injurious extent. There is a provision something resembling this in the articulation of the hind legs; but as these are near the termination of the spinal column, and, as in leaping animals, the weight is thrown from the hind legs, and not on them, concussions on this part of the spine are much less dangerous than on the fore part. In consequence of this, nature, true to the general plan of nothing being made in vain, has been less particular in guarding against such concussions.

The whole body of every vertebrated animal may be said to be composed of a head, a trunk, and limbs. The head contains the brain in its vaulted cell of bone, together with the bones of the face and mouth, which support the organs of feeding, and of those senses which have local seats. The bones of the trunk consist of the spinal column and the ribs, the spinal column having a tube along the centre or nearly the centre of its bones in mammalia and also in birds, for receiving the spinal marrow or continuation of the brain; but in the lower classes of the division, the nervous continuation is external of the jointed part of the bone, and protected only by the processes. The ribs are curves, and secure the sides of the trunk, allowing play to the breathing apparatus. The true ribs are commonly articulated to the processes of the spinal column at the one extremity, and to the breast bone or sternum at the other; but in some cases the sternum is wanting, and in others there are scarcely any ribs.

The extremities or limbs of vertebrated animals are never more than four in number; and of these sometimes the one pair, sometimes the other, and sometimes both are wanting. Those limbs are the proper organs of motion in conveying the animal where it wishes to go, that is, to those places and those substances which are adapted to its habit; and hence they vary greatly in different races. In some they are hands, that is, prehensile or grasping instruments, for man alone is possessed of a true hand—a hand of all work, as we may term it. In others they are feet, or organs simply adapted for motion on the ground; but along with this there are conjoined in certain genera two other faculties, that of seizing the prey with the feet, and that of employing them in burrowing or digging in the ground. In a third modification again, they are wings adapted for the purposes of flight; and in a fourth, they are fins for swimming. There are also some in which two or more of these uses are partially combined, as, for instance, the same organ, in certain aquatic birds, serves as a wing in the air and as a fin under the water; and there are some of the mammalia which have the fingers of their anterior limbs so much produced and furnished with membranes, that they serve as a sort of wings, as in the bats; but the flight produced by such wings is fluttering and laborious, as compared with the flight of feathered wings in birds. The posterior extremities are never wings in any vertebrated animal; but they are hands, or feet, or fins, according to the economy of the different races.

In all vertebrated animals the organs of sense are the same in number, and do not differ much in position, though they differ greatly in form and in power, according to the different necessities of the animals which are furnished with them. There are two eyes for sight, which are so placed as that they are directed to the front, to the sides, or to the rear, and also more upwards or more downwards, according to the direction in which the use of sight is most necessary for the animal. There are two ears for hearing, and their position and development vary perhaps even more than those of the eyes. There are two nostrils, as the organs of smelling; and in all animals which breathe the free air, the air in breathing enters and escapes wholly or partially by the nostrils, so that while the mouth is otherwise engaged, the breathing may be carried on by means of these openings. The surface of the tongue and that of the interior of the mouth generally may be considered as more immediately the seat of the sense of tasting; and this sense evidently varies with the texture of the covering of those parts. The seat of the sense of feeling or touch, and that muscular feeling which is probably the foundation of all the rest, have already been mentioned.

In all vertebrated animals, the mouth consists of two jaws, the position of which is horizontal, the one upon the other; and the lower jaw has in all cases the principal motion, and in some cases the only one. In most animals the jaws are furnished with teeth, which are peculiar bones, growing out of sockets furnished for the purpose, and which vary in the different races. Some vertebrated animals are, however, entirely destitute of teeth in the jaws; and have instead the whole of both jaws furnished with a horny covering, of greater or less consistency, according to the habits of the animal. This is the case with the whole class of birds, with the tortoise family among reptiles, and with some very singular genera of mammalia found in New Holland.

The blood of all vertebrated animals is red; but its quantity and distribution through the body varies considerably in the different classes. In them all there is a circulation of this blood, though this circulation is much less perfect in reptiles and fishes than in mammalia and birds. It is a general law throughout the whole grand division, that the circulation of the blood, and the breathing of the animal, and also its natural heat when in a state of health, are in proportion to each other. If the animal breathes little, its circulation is slow and its temperature cold; and if it breathes much, its circulation is rapid and its temperature warm. We cannot say, however, that either of these is the cause of the other; for they are parts of the same system, and appear to be altogether in proportion to the energy with which the animal is capable of acting, so that an animal with a limited breathing and a slow circulation is always upon the whole a dull and languid animal, however much it may be roused to greater exertion at particular times. In such animals the intestinal canal extends from the mouth to the opening of the body, though it varies much in different races according to the nature of their food. In all of these animals too, the food, after it has undergone the action of the principal stomach, is mixed with two peculiar secretions, the bile from the liver and the pancreatic juice. Indeed the whole of this system bears in its general nature so much resemblance to the digestive system in man, which has been explained at some length in the first part, that it is not necessary to repeat it. In all of them the blood, which furnishes the liver with the materials of the bile which that organ discharges into the intestines, is not sent directly from the heart as it is to almost every other part of the body. It is returned by the veins from the intestines to the vena porta, which appears to partake partly of the nature both of a vein and an artery; and from that vessel it is conveyed to the liver.

In all vertebrated animals, whether they bring forth their young alive or produce eggs, and whether their eggs are hatched within the body of the mother, or by incubation or the mother's sitting on them and warming them with the heat of her body, as in most birds, or left to the casualties of the weather, as in most reptiles and fishes, the two sexes are always distinct and in separate animals. This is not the case with all the invertebrated animals, though it is with many of them; but there are others of them in which the two sexes are conjoined in each individual, so that a reciprocal impregnation takes place.

In those races of vertebrated animals which nearly resemble each other, mixed breeds, or mules as they are sometimes termed, are occasionally produced. In a state of nature such occurrences are rare; but they do happen among domesticated animals, and also between domesticated females and wild males of species nearly allied to each other. If the joint progeny is fertile with the other sex of the same cross, then it is considered that the two species from which it is produced, however they may differ in appearance, are not in reality distinct species, but merely climatal or other accidental varieties of the same one. On the other hand, if the mules do not breed with similar mules, but breed back to what is called the pure blood of either parent, then it is concluded that the parent animals are really of different species.

CHAPTER III.

GENERAL CHARACTERS OF MAMMALIA.

1. General Characters.—2. General Structure.—3. Characters from the Feet.—4. Characters from the Teeth.—5. Range of Feeding.

1. These form the first class of vertebrated animals, and they correspond with what are loosely termed "beasts," or "quadrupeds." Even if we leave man out of the question, and in as far as man can be considered an animal, this is the class to which he unquestionably belongs, there are various reasons why the mammalia should be placed at the head of the animal kingdom. In them the nervous system is the most developed; the organs of sense, taken altogether, are the most perfect; their actions are the most varied; and they have altogether more of what are called sagacity and docility than are to be found in any other class. It would be wrong to consider these faculties as of the same kind with those of man, or to designate the sagacity which we observe in them by the name of reason, even in the very lowest degree. But we see in them the full development of the purely animal system, in the highest degree to which that system can be carried. In them, therefore, we not only see the utmost perfection of the most important part of the creation, but, in the difference

between them and our own species, we may learn how much more we owe to the bounty of that Creator who has set us above them, by endowing us with that immortal principle which shall never die; and as this teaches us the nature of our peculiar privilege, it should also warn us against the abuse of it.

The mammalia are, in some of their races, the largest and most powerful of animals; and when we gather them around us in a state of domestication, they are not only the most useful to us, but they are, to a certain extent, companions and fellow-labourers. Other animals show some sensibility to kindness; but we should search in vain in any other class for the devoted faithfulness shown by the dog, the patient labour of the ox, or the spirit and docility of the horse.

2. In respect of their breathing and the circulation of their blood, and consequently in the average exertion of their systems, the mammalia are only moderate; and thus they are more adapted for prolonged exertion than for momentary efforts of great violence. All the articulations, or joints of the bones, in their skeletons, are fitted for precision and strength; and even in those races which are confined to the water, as the whales, or to very peculiar situations on the land, as the sloths, they still retain all the essential elements of their character. We never mistake even a detached part of one of the mammalia for that of any other animal: a skin, a bone, or a tooth which belongs to any of them, would never be referred to any of the other classes; and such is the peculiarity of their expression, that if we see a single eye, without seeing the animal which it belongs to, we can at once tell

whether that eye does or does not belong to an animal of this class. The eyes of many birds are remarkable for their brilliance, and we know that their owners have wonderful powers of sight; but the eyes of the mammalia speak a language for which we may look in vain in every other department of nature.

Throughout the whole class, in all its varieties, the upper jaw is invariably fixed to the bones of the skull; and the lower jaw is composed of two pieces, which are articulated to a fixed temporal bone. The neck is invariably composed of seven vertebræ or articulated pieces, though in one of the sloths, which from its peculiar habit, has occasion for more than ordinary motion of the neck, the first and second vertebræ of the back have the ribs so merely rudimental, that they have been sometimes mistaken for two additional vertebræ in the neck itself. This however is not the case; for the giraffe, which has the neck of immense length, and the whales, which have scarcely any perceptible neck at all, or any motion in it, both have the regular number of seven bones in this portion of the spinal column. The ribs are attached at their extremities most distant from the backbone, to a breastbone consisting of several pieces. The origin of the fore extremities is never an articulation upon the spinal column, but invariably a bladebone imbedded in the flesh. If the animal has no action of those extremities but simple progressive motion, then this is the whole attachment of those members; but if it has to climb, or otherwise to move those limbs in a direction across the axis of the body, it is furnished with additional bones, which however, connect the shoulder joints, not with the spinal column, but with the sternum or breastbone. These additional bones are the clavicles or collar-bones, conspicuous in human beings from the top of the breastbone to the shoulders; and the use of them is to admit a cross motion of the shoulder joint, which is a motion that no animal which merely walks with its fore legs can possibly perform. The particular mode in which the shoulder joints of the different mammalia are articulated, is a part of their organisation to which too much attention cannot be paid, because it is connected with some of the most important habits of the animals, and we learn from it in few words, that which would otherwise require much observation. The fore limb itself, besides the bladebone, which is imbedded in the flesh of the shoulder, and the clavicles, which, in those animals which have a cross motion, support the shoulder joints, consists of an arm, a fore arm, and a hand, the latter composed first of one row of little bones, called the carpus or wrist; secondly, of another called the metacarpus; and, lastly of the bones of the fingers, which are called phalanges. These latter bones are differently formed according to the use which is to be made of the member, but they are either rudimental or developed in the whole class; and though externally the swimming paw of a whale has some resemblance to a fin, internally it contains nearly the same number and arrangement of bones as the human hand.

In the posterior extremities of the whales there is a different structure from that of the land mammalia, and there is an approach to this in the seals, which are swimming animals, and find their food in the water as well as the whales. In the land mammalia, the bones by which the posterior limbs are attached to the spinal column, form a complete basin or pelvis. In the young state of the animal this pelvis consists of three pairs of bones; the ilia, which are attached to the spine, the pubes, which form the anterior part, or the under and forward part in those animals that have the spine in a horizontal direction; and the ischia, which form the posterior part. At the point where these bones are united to each other, there is situated the cavity into which the trocanter, or round head of the thigh bone, is inserted; for this particular joint has a rolling motion in most of the mammalia, and is capable of very considerable lateral or cross motion in those species which have their posterior limbs terminated by hands, or rather by grasping feet. The thigh bone of the leg consists only of one single bone, the femur, just as the arm consists of a single bone, the humerus. But the leg below this consists of two bones, the tibia, or shin bone, and the fibula, in like manner as the forearm consists of two bones, the radius and the ulna.

This arrangement of the bones, so that there are two in the distal part of the limb which has the most rapid motion, and therefore is the most exposed to accidents, is a very beautiful part of the animal structure, and evinces wisdom and design which are above all praise. The strongest of these two bones in either limb, has something the form of a bow; and the smaller one is applied to it in a manner resembling that of a bow-string. But from the peculiarity of its form, being enlarged at the middle part, this smaller bone is very stiff in proportion to the quantity of matter which it contains. In consequence of this peculiarity of form, and of the manner in which it is applied, the small bone acts upon the large one in that way which carpenters call "both a tie and a strut," that is, it equally prevents the ends of the large bone from being pulled asunder and pressed together; and thus it gives far more strength to the part of the limb in which it is found, than if that had consisted of one bone containing the same or near double the quantity of matter that there is in the two. It is this union of the greatest possible degree of strength with the least possible quantity of matter, which makes the structure of animals so perfect in a mechanical point of view, compared with anything which human skill can contrive.

The posterior extremity is terminated by the foot, which bears some resemblance to the hand which terminates the anterior extremity. Like that, it consists of three successive sets of bones, which are called the tarsus, the metatarsus, and the toes, the latter consisting of phalanges, as is the case in the bones of the fingers.

The brain in all the mammalia is well developed as compared with that in any other class of animals; and it is amply defended by the skull. The organs of sense are also all well developed, although in those species which live in the water, the external ears are very imperfect. It does not appear, however, that this is any very serious impediment to their hearing. All the mammalia have the tongue fleshy and adapted for an organ of taste; but the degree of acuteness in this most probably varies with the covering of the tongue, being less acute in such as have the tongue rough, or studded with hard papillæ, or with small teeth, as it is in the cat family. We shall not farther enter into any general account of the structure of the mammalia, which however reaches to all their functions, and to all the parts of their economy; but we shall shortly notice the grounds upon which the class may be most correctly as well as most conveniently divided into orders, in accordance with their organisation, and consequently with the habits for which that organisation is, in all cases, adapted.

3. The most essential differences in the mammalia, are those of the organs of motion and prehension, by which they are conducted to their food and enabled to seize it; and their organs of mastication, by which their food is prepared for digestion in the stomach.

The portion of the organs of motion and touch in which we are chiefly to seek those general characters which guide us to the nature of the haunts, the habits, and, to a considerable extent, the food of the different races, is the structure of the last, or distal one of those three parts, of which, as we have said, the limb of all the mammalia is composed. On the anterior limbs this distal portion is the hand, and on the posterior one the foot.

But when man, whose peculiar structure in this, as in all other respects, entitles him to be considered as perfectly distinct from all the others, is left out of the question, we find a great degree of similarity in all the four feet of each of the other mammalia. No doubt we must take man as the grand typical animal in this respect,—the one in which the hand and the foot are respectively most perfect in themselves and most distinct from each other. This is of great value to us in examining the structure, and judging of the uses of the corresponding parts in all the other mammalia; and their general relations are, when rightly used, the keys of knowledge.

Now the human hand is a perfect and universal hand, *the hand* by way of eminence; but it is simply a hand, and nothing else; and when man attempts to use it as a foot, in walking, the operation is equally painful and unsightly. So also the human foot is a perfect and universal foot, a foot so well adapted for walking upon surfaces of all kinds, that we cannot say, as we can say of the feet of almost every animal, that "the march of this foot is necessarily confined to certain parts of the earth." But still the foot of man, though a perfect foot, is only a foot, and possesses none of the characters or functions of a hand. Thus, in man, we have each of the two kinds of terminations of the limb, perfect and distinct from the other.

It cannot be urged in opposition to this, that there have been instances of human beings, who, being wholly without hands, have been able to perform with their feet many of those operations for which the hand is chiefly used; for there have been others, who, wanting both hands and feet, have performed very nice operations, such as painting pictures, with the mouth or the top of the shoulder. This shows that the hand, wonderful as it is in its structure, is not the workman but only the tool; and in this resource which a human being finds under what must be regarded as the greatest of all bereavements in the way of action, is perhaps one of the most convincing proofs which we have, that the resources of man depend upon a principle of a higher order than any which belongs, or can belong, to the other animals—to beings which return wholly to the dust when the appointed days of their lives upon the earth are numbered.

The extremities of the limbs in the other mammalia, are never perfect hands or universal feet, as they are in man, though in the different orders they vary, from partaking more of the character of hands, to partaking more of that of feet. When they have the hand character, however, it is always in the simple form of grasping or prehensile hands; and though the anterior ones have perhaps this property in a higher degree, as they have more offices to perform, the hind ones are in every case only fit for grasping and climbing; but in addition to taking their part in this, the fore ones have often to seize the food to convey it to the mouth, to hold it while it is eaten, and sometimes to prepare it for eating. When they have all these offices to perform, they make of course the nearest approach to the typical or human hand that can be made by any of the lower animals.

When the extremity of the limb has more the character of a foot than that of a hand, it does not incline toward the type of the human or universal foot, but to that of some one particular foot, adapted for walking on one particular kind of surface, but not on surfaces generally; and this again points out to us that these animals are local in nature, fitted only for particular places and departments of it, and have not the universal adaptation and resources of man.

Besides climbing, the operations which the feet of the mammalia have to perform, in addition to those of locomotion, are seizing the prey and digging or burrowing in the ground. Both of these require considerable development and perfection in the phalanges of the toes; but different forms of the claws, or horny armatures of the extremities of them, are required for the two operations. The preying foot, or paw as it is usually called, is furnished with sharp and crooked claws, which, in the more typical animals of this kind, as in the cat, from the lion downward, are more or less retractile, that is, capable of being withdrawn into sheaths, and having their sharp points protected while the limbs are stretched in walking. But even in these claws there is a most beautiful motion, which shows the amazing wisdom with which everything in creation is fitted to its use. When the limb is extended, and the protusion of the claws would injure them as instruments of prehension when the time of catching the prey arrives, the claws are drawn in, not by any muscular effort requiring labour on the part of the animal, but merely by the elasticity of the ligaments. In like manner, when the claws are protruded so that they can act, their action is occasioned, not by a muscular effort which would require exertion, and waste the strength of the animal, but simply by the same power of elasticity in the ligaments. This fact of throwing many of the most severe and continued actions of animals altogether off the animal or living system, and upon the simple properties of matter which need no exertion of animal life, frequently occurs throughout the whole range of the more active animals, and is one of the most wonderful provisions which they display.

In proportion as the extremities of the limbs are less developed, the toes fewer in number, and their phalanges less perfect, and especially in proportion as the whole of that portion of the foot which comes in contact with the ground is covered with horn or any other insensible substance, the foot may be considered as losing its prehensile character, and becoming more exclusively an instrument for walking. There is a remarkable instance of this in the foot of the horse, as compared with that of the elephant. The foot of the horse has the whole of its extremity enclosed in one horny hoof. The foot of the elephant has the toes but little produced without the integuments, but they are otherwise free. Thus the elephant can use the foot along with the proboscis, as a sort of hand; while the horse, which has apparently the more handsome foot of the two, can make no such use of it. The feet of the mammalia, and the peculiar kind of ground and of action upon that ground, open a very wonderful field for our contemplation; but this field is as wide as it is wonderful; and we have merely hinted at it to show of what great use it must be in the natural knowledge and classification of these, the most interesting of all animals.

4. Another part of the structure of these animals which serves to guide us to the knowledge of their general character (and it is the last to which we shall advert) is the character of the teeth. Contrary to what those who have not reflected on the subject would be apt to suppose, the teeth, upon which the character of the animal in respect of the nature of its food chiefly depends, are not those which are most in sight, or appear the most formidable when we examine the mouth of the animal. The tusks of the elephant and the wild boar though they appear so large and formidable, are not intended to make an unprovoked attack on the

life or safety of any other animal; and there are harmless animals possessing very large teeth in the very places of the mouth where the larger beasts of prey have their weapons of slaughter.

The teeth which are most characteristic of the food of the animal, the nature of which is one of the most essential elements of its general character in nature, are not the *incisores* or cutting teeth in the fore part of the jaws; for these are often most formidable in timid animals which live wholly upon vegetable substances, as in the hare and the beaver; neither are they the *canines*, or dog teeth, at the angle of the jaws, or just behind the cutting teeth, for the tusks of the elephant and the boar, already alluded to, are of this kind, and their teeth are also very much produced in other vegetable feeders, such as the musk deer. The really characteristic teeth are the cheek teeth, improperly called *molares*, or *grinders*, because those animals which have these grinders and a grinding motion of the jaw are all vegetable feeders. This grinding is their distinguishing character, in so far as that depends on the teeth. Those which feed upon insects and other small animals have the tops or crowns of the cheek teeth formed into little knobs, or what are called *tuberculated* teeth, which, again, is their character, in as far as their character depends on the teeth. The teeth which are more peculiarly fitted for tearing, dividing, and bruising the flesh of warm-blooded animals have trenchant edges formed something like the teeth of a saw, with one larger point in the middle and a smaller one before and behind it. These are the true *carnivorous*, or flesh-eating teeth; and an animal is more or less given to kill living warm blooded animals and eat their flesh, in proportion as it is more or less furnished with teeth of this description.

Though those forms of the teeth are among our best guides to the general characters of those animals in which they are found, the characters to which they guide us are only general and not absolute. For in every animal there is a certain range within which it can subsist in respect of food as well as of everything else. Even the lion, which in a state of nature is among the most carnivorous of animals, can be brought to feed in part, at least, upon the pulpy and farinaceous parts of vegetables; and some of those animals which, in a state of nature, are the most exclusively vegetable feeders, can be brought by necessity to eat animal substances. It is very commonly said that in some of the northern islands, as for instance in Shetland, the cows eat herrings, and resort to the sea in the winter to feed upon such animal remains as the tide leaves along the shore. We also know that, on the common pasture, and when there is no necessity in the want of vegetable food to drive them to such an alternative, cattle will often gnaw bones, old shoes, and other animal remains. But still, notwithstanding these and many other exceptions which could be mentioned, the general character of the cheek teeth of any of the mammalia is the most certain guide that we have to the general nature of its food.

5. This range, in respect to the nature of that on which it subsists, that every animal is capable of taking when the necessity of the case requires, is one of the most remarkable instances which we have of the provident bounty and goodness of Him

to whom all are indebted for the origin and the continuation of their being. We, notwithstanding all our reason,—which, in our weakness, we are often but too apt to boast of, rather than to turn to the proper account in true knowledge of our Maker, and humbled obedience to his law and will, natural and revealed,—we, notwithstanding all this, are unable "to tell what a day may bring forth;" and if this be our case, endowed as we are, what can we think of the other animals, which must depend upon instinct alone? Therefore, the fulfilment of the gracious promise that "they shall not want," required some such adaptation to circumstances as that which has been mentioned. Those general causes, but little known even to us, which act powerfully upon large portions of the surface of our mortal dwelling, sometimes completely destroy the one peculiar and most favourite food of one kind of animal, or they reduced it so low that what is left is not more than enough for the mere continuance of the race. They take away the prey, but they at the same time leave the preyer; and if that preyer could not turn to some other resource, the loss of one would soon become the loss of all; for the whole of the living world are, in a state of nature, dependent upon each other.

We find a remarkable illustration of this when we turn our thoughts toward ourselves. We, as has been said, possess the universal hand for working, and the universal foot; and, it is not a little worthy of remark that, along with this universality in doing and in moving, we are at the same time the most universal feeders under the canopy of heaven. It is true that we have the means of preparing and tempering our food by the culinary art, before we take it into the mouth and subject it to the action of even those organs which give it the first preparation of the stomach. But still, in the nearest approach that the human race makes to being absolutely in a state of nature, the resources which they have in the way of food are much more numerous than those of any other animal. In that state they extend to a great number of animal and vegetable substances, and, as is said, in some instances even to the earths. Humboldt mentions that some of the wild tribes in the valley of the Orinoco live wholly or chiefly upon clay at a certain period of the year. This is contrary to our common notions certainly; but we are not warranted in saying that it is impossible. The simple elements of which the human body, like the bodies of all other animals, is composed, are carbon, oxygen, hydrogen, and nitrogen, all of which may exist separately in the state of gas; and although the food of man, and of all the mammalia, in the ordinary way, consists of organised substances, taken into the stomach for the purpose of being digested and assimilated by the nutritive system of organs, we do not know to what extent the body may, upon emergency, be capable of absorbing those elements by other means. We know that those whose bodies are exposed to certain steams and vapours become and continue fat with very little direct feeding by the mouth; and we also know, that those who are exposed to steams and vapours of other kinds remain thin and spare with the most sumptuous feeding; but the rationale of the matter in both is without the pale of our philosophy. We see enough in it, however, to convince us, that we must not confine our opinions of nature to any one limit that we can form.

Viewing the almost universal adaptation of the hands and feet in man in conjunction with the very miscellaneous nature of the food upon which he can not only subsist, but enjoy equal health, and exert equal strength, we naturally conclude that in proportion as other animals are more general in their adaptation, they also must be more miscellaneous in their feeding. In this, however, there is one precaution with regard to the feet, of which we must be careful not to lose sight. In so far as the feet of the animal merely serve the purpose of conducting it to its food, they do not, whether they are grasping instruments or mere instruments of motion, give us any information as to the nature of that food. It is only in so far as the feet are evidently instruments of prehension, directly employed in seizing the food, striking it down, or otherwise bringing it within the power and possession of the animal, that we can infer the nature of the food directly from them. Thus the fore feet of all the apes and monkeys are fitted for grasping and pulling, but not for wounding or inflicting any serious injury upon a living animal of any considerable size. From this we would very naturally conclude, that one principal part of the food of these animals is fruits of different kinds, which they pull from the trees; and that if, in addition to this they feed upon animals, it can only be upon insects, and other very small ones which they can take into the mouth entire. On the other hand, when we examine the paws of any animal of the cat family, we can have no hesitation in pronouncing at once that they are decidedly preying instruments, and that even their use to the animal in walking is subordinate to this one. In this case, as well as is the former one, the observed facts completely verify the conclusion at which we arrive from the examination of the organ. Even the common cat never attacks living prey, or prey in motion, which seems to be the test of life to these animals, but with the paw; for if that prey is only a fly, the paws are always put in requisition against it.

If the foot is not so directly a clutching instrument, but is something intermediate between a hand and a foot, adapted for a peculiar seat of locality—as we have mentioned is the case with all these terminations of the bones of mammalia which are feet and feel only—then we must conclude from this, that the animal is more miscellaneous in its feeding, and must refer to the teeth and other parts of the alimentary system, to ascertain to what extent it may or may not be carnivorous; and our inference must in a great measure be regulated by the number of teeth which have the true carnivorous character, accompanied with those that have it not.

Feet adapted for motion only guide us to the haunts of the animal, and we must have recourse to the teeth and the digestive organs for the general nature of the food. Thus, for instance, the hog and the sheep both have the foot with a divided hoof; and all that we can conclude from this is that in both the foot is merely a walking instrument. But when we turn to the teeth, we find them very different. The hog has all the three kinds of teeth, incisors, canines, and cheek teeth; but none of the latter are of the carnivorous character, they have the crowns only tuberculated, and thus they are adapted for bruising only, and not for cutting and tearing. Hence we would conclude, without further observation, that the hog is a miscellaneous feeder, but not naturally a carnivorous animal. On examining the habits of the hog, we find that it has no objection to animal garbage, but that when it meets with anything that requires cutting or tearing, it brings the foot into action, in order to hold on. Hence the common remark, that nobody ever saw two hogs feeding without one having its foot in the trough. If, in like manner, we refer to the teeth of the sheep, we find that it has eight chisel-shaped incisors in the lower jaw, and none in the upper, and no canines; but that it has six cheek teeth in each side of both jaws, with thin crowns furrowed like millstones; hence we conclude that the sheep is a vegetable feeder, and not a miscellaneous one.

The instances which are here given are those of animals with which every one is well acquainted; and we have purposely taken such, in order that the reader may better see the force and use of this application; for it will be found, that every animal which exactly agrees with any of these in the structural characters to which we have referred, agrees equally with it in its general habits.

Other characters might be mentioned, the differences of which indicate the different habits of the animals in which they are found: and every character of this kind has its value in carrying us from the known to the unknown, which is the end and purpose of all true and useful philosophy. Indeed it is the grand advantage of these general characters of the works of creation, that they not only lead us to a far more extensive and useful knowledge of the creatures than we can obtain by any other means; but we are also more powerfully and pleasantly drawn to the contemplation of that wisdom and goodness which made and which governs the whole.

When we contemplate the creatures in nature, we ought to bear in mind that the Almighty is both the shepherd of the whole flock, and the lord of the whole pasture; and that, therefore, we may be prepared to expect that the one part will throw light on the whole, and our prospect will brighten and broaden, till, to our grateful and delighted mind, "the earth" shall appear "full of the glory of the Lord."

CHAPTER IV.

ORDERS OF MAMMALIA.

1. Names and Distinctions of Orders.—2. Four-handed Animals.—3. Carnassiers.—Cheiroptera; Insectivora; Carnivora (plantigrade) (digitigrade) (amphibious).—4. Rodentia.—5. Edentata.—6. Pachydermata.—7. Ruminantia.—8. Cetacea.—9. Marsupialia.

1. Chiefly upon the characters which we noticed in the section immediately preceding, but with occasional reference to others, as may be necessary, the mammalia are arranged into orders, and those orders into smaller divisions and genera, according to their structure, and their habits as intimately connected with that structure; and, by taking this method, we are enabled to gain as much knowledge of the whole as may answer for all ordinary purposes, and that with even less labour and time than would be required for fully understand-

ing only a few species, if we took the other method and went to the details without knowledge of the principles.

Order 1. — *Bimana*, two-handed. The only species which this order contains is man; and, for the reasons which have been already given, man does not properly, as man, in the most exalted and best sense of the term, belong to this division of the philosophy of nature. But let man learn of the other animals: let him go to the beasts of the field, and they will give wisdom; to the fowls of heaven, and they will teach understanding. No future day of retribution awaits them, and yet there is no error in their ways, no part of their duty left undone; therefore, let man, for whom the hour of retribution is surely on the wing, take heed to his steps, lest when he comes to be weighed in the balance he should be found wanting.

Order 2.—*Quadrumana*, four-handed. This is a very numerous order, comprehending the apes, the baboons, the monkeys, and some other animals, all of which have the extremities of both the fore-feet and the hind ones constructed something like hands. They are however hands for taking hold, and not hands for working; and a beaver with its teeth, a bird with its bill, or even a coral insect, which not only has no visible organs, but is hardly discernible as a whole, is a better builder than all the four-handed animals upon earth. Notwithstanding this, the four-handed animals are not less perfect in their kinds than the creatures which construct the most curious fabrics. "Solomon in all his glory," was not equal in the beauty of his apparel to "the lilies of the field," and yet "they toil not, neither do they spin."

Order 3.—*Carnassiers*, eaters of animal substances. This is a very extensive order; and as the character on which it is formed is not a simple or a constant one, it is not so natural as some of the other orders. Animal substances may be the bodies of the warm-blooded animals, killed by those that eat them; they may be the invertebrated animals killed in like manner; they may be the eggs of animals before they are quickened into life; or they may be the remains of animals which have died in the common course of nature, or by other means than the direct attack of the preyer. An animal that eats any one or more or all of these, is a feeder upon animal substances. But these kinds of food are so many and so varied, that the feeders require to be as many and as varied as the food; and, therefore, we might be prepared to expect that this order of animals would require division into many subordinate groups and sections. Such, in fact, is the case; and yet the order does not comprise the whole of those mammalia which feed upon animal substances, or even which kill other animals, on purpose to eat them; for there are others which cannot well be included in this order, which have this habit, at least occasionally. It is to be understood, however, that all animals which are properly carnassiers, and as such included in the order, prefer animal food of some kind, and in some state, to food of any other description; and this is the utmost precision that can be given to any definition which will apply to the whole.

All animals which belong to these first three orders, or to the two, leaving out man, have one character in common. They have all the three kinds of teeth, incisors, canine teeth, and cheek teeth.

These vary greatly in form according to the nature of the animal's food; but still they are always present in some form or other; and it is also worthy of remark, that those animals which, as one would say, have the mouth the most perfect, or at all events the most developed, have also the whole animal system better developed, and possess more resources, or, as it may be expressed, a wider range of instincts, than most of the others. It is true that in many animals, and in every production of nature, we find manifestations of wisdom which we must admire, though we cannot imitate; but we find more of it in these animals, than we do generally in the other orders, or at all events it comes more home to our ordinary understanding.

Order 4.—*Rodentia*, open-toothed, or gnawing animals. The character upon which this order is formed is, again, a simple one; and therefore this is a more definite order than the third, though it contains animals of very different dispositions and habits. The character is that of the teeth, of which the animals have only two kinds, incisors in the front of the jaws, and cheek teeth behind, with a blank where other animals have their canine teeth. It is from this gap or opening between the cutting teeth and the grinders that the order gets its name. This opening is not a fault in the mouths of those animals which have it, but rather a decided advantage, as indeed are all the structural peculiarities of animals, however irregular they may appear to us, when we do not take the trouble of informing ourselves with regard to their uses.

The peculiar habit of these animals in feeding is to gnaw hard substances, generally vegetable ones, though they are not exclusively confined to vegetable food. The gnawing teeth are placed far forward in the jaws, have their edges in the form of chisels, and, generally speaking, continue growing during the lives of the animals; so that though they wear down by the hard labour which they have to perform, they are supplied at the roots as fast as they wear away at the cutting edges. Their cheek teeth are calculated for bruising hard substances; and many of them live upon the bark of trees, and some even upon the branches; this last is the case with the beavers, which collect a pile of sticks for their store of food during the winter. Hares, rabbits, rats, and mice, are familiar instances of animals of this order.

Order 5.—*Edentata*, toothless animals, or, more strictly speaking, animals with the teeth imperfect as compared with the first three orders, which have all the three kinds of teeth. These are altogether very singular animals, of which none are found in Europe, or in any country resembling it; and among them are included some of the curious animals of New Holland, which, though true mammalia in the essential parts of their character, yet, in some particulars, have a slight resemblance to birds in some parts of their external appearance, and also of their internal formation.

Order 6.—*Pachydermata*, thick skinned animals. The thickness of the skin is not a very definite character upon which to found an order of animals; but as applied to those which are collected into this order, it is almost the only one which can with propriety be applied to the whole. As land animals now exist, the largest in size are included in this order; but they do not agree in very many of their characters. The horse, the hog, and the elephant are examples of the order.

Order 7.—*Ruminantia*, animals which chew the cud, or bring up the food from the stomach to undergo the process of mastication in the mouth. As the character upon which this order is founded applies to the whole system of nutrition, and the feet, though they differ in form according to the nature of the ground which the animals inhabit, are still only walking feet in all the species, without any power of being brought to the mouth, or acting in any way across the axis or plane of the body, the order is a very natural one. The animals composing it are the true herbivorous animals, or genuine vegetable feeders.

The greater number of them, indeed we may say the whole, are social, and live in greater or smaller herds, according to the species and the nature of the pasture. This social disposition, which they have in a state of nature, predisposes them for domestication by man; and hence they are the proper domestic animals,—the most valuable, in an economical point of view, in the whole animal kingdom. Their flesh supplies the best, most abundant, and most wholesome food; their hair and wool the best and warmest clothing; their milk is more wholesome and abundant than that of any other animals; their skins form the best and most durable leather; very many of them are fellow-workers with man in the labours of the field; and instead of being injurious to those places where they pasture and feed, they are among the principal means by which the wild places are brought into a state fit for the plough, and again restored after having been exhausted by a succession of crops.

Furthermore, they are, in one or other of the species, adapted to every country and every climate. The camel—"the ship of the desert," carries man and his merchandise across the burning sands, and enables a communication to be kept up, and mutual help afforded, and civilization promoted in those ardent climates where, but for this powerful and patient animal, man would be cut off from the fellowship of man; and as man sharpeneth man, even "as iron sharpeneth iron," it is the journeyings of the camel which have, more than any other natural causes, rescued the human race from utter wretchedness in those parts of the world.

Yea, in the most dreary regions of the north—the extremest bounds of the habitable earth, where the snow but too often descends ere the scanty harvest is gathered in, and the sun of heaven withdraws its shining for weeks and for months, where the rivers are hardened into stone, and the waves of the sea congealed mass upon mass, and flung in heaps by the last struggle of the contending wind and flood, ere nature submits to the cold and still dominion of the polar winter,—even there, man is not forsaken by this faithful and all-serviceable order of animals, for there, amid the thick darkness of the sunless months, the right hand of his Maker finds him out, and, through the instrumentality of the rein-deer, bears him as freely and as fleetly over the polar snow as a bird is borne through the air, while the flesh of the same wonderful animal supplies him with food, and its skin, impenetrable by the keenest wind, protects him from the cold. Thus we find that in those remote places where the furrow refuses to yield an increase of any sort of grain fit for the food of man, the ruminant animal becomes his only wealth and his only resource; and so well is that animal adapted to those peculiar countries in which alone it is found, that its favourite food is almost the last lichen or hard plant of the rock, which grows fast by the extreme boundary of animal and vegetable life.

In climates of more temperate character, which vary only as we descend into the valley or climb the mountain height, we find those animals still ready to administer to the wants of man, at what elevation soever he may pitch his abode. In the rich meadows and wide savannahs by the banks of the great fertilising rivers, the stately ox collects his multitudes, and dispenses plenty all around. The dry upland is spotted over with the gentle sheep; the mountain crags are overhung with the browsing goat; and, far above all human habitation, the chamois and the ibex bound from rock to rock, as if the same power which ordained them their lofty dwelling had given their feet some of the attributes of wings. In the wide plains of the African continent, where fertility and famine divide the year, innumerable herds of antelopes bound from pasture to pasture, far more fleetly than the deer on our mountains; varieties of the same curious and beautiful race follow the margin of the desert, through southern Asia, and abound in all the sunny lands of the East; nor must we forget that species, the beauty and the fleetness of which is so often referred to in the inspired volume—

"The wild gazelle on Judah's hills."

Order 8.—*Cetacea*, whales and whale-formed mammalia. This is also a very natural order, although founded rather upon the element in which the animals live, and their adaptation to that element, than upon anything connected with their mode of feeding and general disposition as connected with that. They are all animals having red and warm blood, having their bones more resembling the bones of land animals than those of fishes, breathing the free air by means of lungs, for which purpose they must at short intervals come to the surface of the water, bringing forth their young ones alive, nourishing them with milk,and watching over them with the same solicitude as those nursing mothers which dwell upon the land. They all have the bones of the lower cavity, or pelvis, nearly obliterated, and the spinal column produced and ending in a tail, which, however, consists of muscular fibres and membranous tissues, without any rays like the tail fin of a fish; but as the mammalia generally have a higher degree of animal development than the colder finny tenants of the flood, the motions of these animals exceed those of any of the fishes properly so called; and as some of the species far exceed all other animals in size, their power in the deep is almost beyond our imagination.

Thus far the whole of the order agree with each other; but beyond this there are remarkable differences in the food and the feeding, and consequently in the disposition. Some browse the weeds at the bottom of the water, and the plants on its margin; and these are as gentle in their manners as the oxen in the meadow, nor does their flesh differ greatly from the flesh of oxen either in taste or in quality. These are found only in the fresh waters of warm countries, and therefore they do not require to have the vital parts of their bodies protected by a thick layer of oily fat under the skin.

The greater number, however, inhabit the ocean, and it is probable that some of the larger ones range the whole of its wide expanse with the same freedom as oxen range a meadow, or sheep a hill pasture; the rate of their motion through the water being estimated at upwards of a thousand miles in the day. But even of these giants of living nature, some are as harmless and as gentle as lambs. The common black whale of Greenland, whose numbers have been so much thinned by annual fishing in polar seas, has not a tooth, nor the capacity of swallowing a substance larger than the human hand when closed, or even so large. This catches in its whalebone net, as it swims along, the small animals which float in the water; and as it apparently feeds with less exertion of its general system than any other living creature, so it is generally the fattest of the whole. Other whales are without the net, have their mouths more formidably armed, are very voracious in their feeding, can swallow a fish sixteen feet long; and as these, and not the black whale, are the ones found in the Mediterranean, it is probable that they are the fish alluded to in the book of Jonah. Some of the smaller ones are exceedingly voracious; and we find porpoises and other small cetaceæ pursuing the salmon up the estuaries of our rivers, and devouring them in vast numbers.

Order 9.—*Marsupialia*, pouched animals. These are a curious race; and appear as if they belonged to a distinct class of animals from the common mammalia. Their very expression is different. They have a wild and wandering look, their covering, their structure, and even the places where chiefly they are found are all peculiar. Some are met with in America, as far north as the United States; and there are some also in the south eastern countries of Asia; but they appear in both of these as scattered remnants, having little kindred with the other and more numerous and characteristic of the native mammalia. Australia, that vast extent of country, which lies to the south east of Asia, and which even yet is but imperfectly known, is their head quarters; and they are its characteristic and probably its only aboriginal mammalia.

Nor must we omit to remark, that while those animals of this singular part of the world seem to stand lower in the scale of animal development than the mammalia of other countries, even so, when these lands were first visited by Europeans, their human inhabitants were lower down in the scale of understanding than the natives of any other region. They possessed cunning, and had weapons of destruction, in the use of which they were dexterous; for it seems to be a part of the natural disposition of frail and fallen men, that the first art which they learn is that of destroying one another. But they had no houses, few accommodations of any kind, no history, no superstition, and no bowels of mercy for the diseased and the aged; for, among them, all such as were unable to provide for themselves and maintain their ground, had nothing left but to creep into holes and caves of the earth, and there lay themselves down to die, without pity and without hope.

When we think of these things, how grateful ought we to be to the Almighty for that, of his gracious mercy to us, "The sun of righteousness hath arisen with healing under his wings,"—that the Gospel of Jesus hath come unto us in its purity and its power; not only bringing life and immortality to light, but calling forth and nourishing all the kindly charities; giving science the eye of the eagle, art the hand of the cunning workman, and knowledge with all its benefits the wings of the wind, so that they have spread, and are spreading to the uttermost parts of the earth, and will spread, until all nations, and kindred, and tongues, and languages shall unite in one grateful song of jubilation and of joy: "Glory to God in the highest, on earth peace, good will to the children of men."

In the form of their feet those animals vary much according as they are adapted for one sort of surface or another; but still they are all toed animals; and the toes are generally well developed. Their teeth also vary considerably; and some of them are adapted for killing living prey, and others for feeding upon vegetable matter only; yet, even here too, there is a sort of family likeness among them, and a difference from the other mammalia. Indeed, one who is familiar with animals would have no great difficulty in ascertaining by the sight of even a part of one of these, that it was a marsupial animal.

The grand distinguishing character, however, is the marsupium or pouch on the abdomen of the female. This is more developed in some of the species and less in the others; but it belongs to the whole, and there are two additional bones in the skeleton for the purpose of supporting it. It opens to the front; and in the more typical races extends as far forward as to contain all the mammæ or suckling apparatus. This apparatus is somewhat different from that of the common mammalia, because the young have recourse to it for support at an earlier stage of their existence. They are brought forward for some short time in an internal matrix, as is the case with the others; but they do not remain there till they are capable of exercising any of their external powers, or even till they have acquired the form and the limbs of the perfect animal. In the case of the great kangaroo, one of the most typical of those animals, and the only one which has been observed with the requisite attention, the young remains in the internal uterus for about twenty days, at which time its body is little more than an inch in length, but at this early stage it changes its abode and way of nourishment. The mother transfers it to the pouch by means of a mouth, where it soon adheres to a nipple, to which it remains attached until fully developed and capable of motion. At the time of the transfer, its different organs are merely traceable; and there is not a vestige of hair on its body, which is semitransparent, and in colour not unlike a common earth-worm. After the young have been so far brought to maturity, as that they can partially find their own food, they occasionally return to the pouch, in which the mother carries them from place to place. The larger animals of this order, which have the pouch more fully developed have the hinder part of the body very large and strong as compared with the fore part; they perform their principal motions by leaping on the hind legs; and their tails are so large and strong, that upon occasion they can bring them to the ground as a third foot, not for motion, of course, but for support. Among the common mammalia, almost the only animal which can use the tail in this manner is the beaver, which is thus enabled to stand as it were on three feet, and thus support itself without leaning against its work, while the fore feet and the mouth are occupied in building or repairing that curious dwelling which it erects for itself. It is not true, however, that the beaver uses its tail as a spade, a trowel, a mallet, or any of those instruments for which the earlier describers of animals have represented it as being a substitute.

Such in brief outline are the principal orders into which the mammalia have been arranged by those who have attended most carefully and most philosophically to the organisation and the habits of the different members of the animal kingdom; and we shall now turn back and very briefly notice some of the leading habits and subdivisions of the principal orders, so as that we may understand the place which they hold, and the part which they act, in the grand system of creation.

QUADRUMANA.

It has already been said, that this order comprises all the animals which have the four extremities formed for grasping rather than for walking on the ground; and there are some of them in which the tail, which in these cases is usually very long, comes in as a fifth grasping instrument, being prehensile, that is, capable of curling round the branch of a tree with so much firmness as that the animal can suspend itself by it, and by swinging both its body and the elastic branch round which the tail is curled, contrives to reach other branches which it could not possibly do by grasping.

Before the philosophy of natural history was properly understood, and the uses of organs were considered along with their structure, it was not unusual to make man the standard of judgment in the case of all animals; and it is a remain of this system which still leads naturalists to place the grasping animals at the head of the irrational mammalia. Upon purely philosophical grounds, that place ought certainly to be given to those animals which are the least confined to one particular locality, mode of life, and kind of food, and which have consequently the greatest sagacity and the most numerous resources. In this view of the matter, none of the four-handed animals are entitled to take the lead; for the dog is unquestionably superior to them all, and in adaptation to climate, miscellaneous food, and number of resources, the family of animals to which the dog belongs is certainly superior to all others.

It is true that in some parts of their structure many of the handed animals have slight resemblances to man; but it is worthy of remark, that those which resemble him the most in one particular resemble him less in some others. Thus the apes without tails, the chimpansee, the ourang-outang, and the others of that division, have the canine teeth very little longer than the other teeth, they have certain parts of the body nearly destitute of hair, and some slight resemblance to human beings in the form of the head, though none in the nose and chin. But these animals have no cheek pouches; and some of them have the fore legs very long in proportion to the hind ones, while all of them are bad walkers.

The chimpansee is an African animal, not very large in size, with remarkably large ears and the nose flat, and though it can walk better than some of the others, its walk is very shambling, as the feet partially turn the soles inward. The ourang-outang is a native of the eastern islands, considerably larger in size than the chimpansee, with the fore legs reaching the ground when the body is erect; whereas, in the chimpansee, they do not reach lower than the knee joints; and in the ourang-outang the feet are still worse adapted for walking, as they turn fairly on the outer edge when the animal applies them to the ground; and thus even with the assistance of its long fore legs, its march is exceedingly awkward and laborious.

The different localities to which these two species are adapted, will show the size of their different structures, and also throw considerable light upon the part for which the whole order have been formed for acting in the economy of nature. The chimpansee lives in those parts of Africa where the forests are not continuous, but consist of a succession of thickets and detached trees; so that this animal has to pass on the ground from thicket to thicket, or from tree to tree. The ourang-outang, on the other hand, (and there are two or three other species in the same countries bearing much resemblance to it) inhabits countries where the forests are thick and close, and there is little occasion for a tree animal ever descending to the ground; accordingly it is less adapted for walking than the chimpansee, but much better for making its way among trees, not only on account of the length of its legs, but of their articulation; for the hind legs have nearly as much motion across the axis of the body as the fore legs, so that what we call the foot can be stretched out sideways to reach a branch with nearly as much ease as that which we call the hand. All those apes which have the teeth even are forest animals, and feed almost exclusively upon vegetables; they are quite helpless out of their forests; and though not very vicious animals, man can turn them to no very useful purpose; for though it is highly probable that their flesh would be wholesome as food, the form of their bodies occasions a sort of repugnance to the use of it for that purpose. The digestive organs of animals are always in accordance with the teeth, as forming part of the same system; but no inference with regard to the intelligence and resources of the animal can be drawn from this, because it is a part of the vegetative system only, and not of the sentient; and, therefore, though the stomach and bowels of those tailless apes are very similar to those of the human subject, it by no means follows that any physiological resemblance can be founded upon this. The digestive organs of the pig more resemble the same parts of man than those of the dog do, but no one would argue thence that the pig must necessarily make a nearer approach in sagacity to man than the dog does.

The tailed apes, or monkeys of the eastern world, are smaller in size than those to which we have alluded, and they are also vastly more numerous, swarming in all the tropical forests to such an extent as that they actually stun the traveller with their noise. They are also much more gregarious; and they often leave the woods and commit terrible devastation on the fields and orchards of those who cultivate the ground near their abodes. Being lighter than the apes, properly so called, they are much more agile; and they skip and play among the branches with vast celerity. Like the former they are chiefly vegetable feeders; and of course not naturally ferocious animals; but they are capricious and mischievous, and for domestic purposes entirely useless. Indeed, we may remark of the whole order, that they belong exclusively to the rich places of the earth in a state of rude nature; and that when man takes possession and cultivates, their function ceases, and, if they are allowed to remain, they do nothing but mischief.

The baboons form another division of this order, and they, like those mentioned, are all inhabitants of the warm parts of the eastern world. They are not so exclusively climbing animals as the former, and therefore their feet are a little better adapted for walking. Those baboons differ considerably in the several species; but generally their bodies have something the resemblance of those of predatory animals, with the canine teeth considerably produced, generally very repulsive in their appearance and ferocious in their manners. Some of them are as much as between five and six feet in height when they stand erect, and very strong in proportion to their size. One species of baboon, usually called the Barbary ape, is met with in Europe, but, we believe, only upon the rock of Gibraltar; and this is the only species of the order which occurs in our quarter of the world.

On the American continent, that is in the tropical part, where the forests are very numerous and extensive, there are many handed animals. These are generally of small size, with the extremities very long, and many of them having the tail prehensile in the way that has been stated; and of those American ones there are some which are even more noisy than those members of the order which inhabit the east.

When we arrive at what may be considered the termination of this order, the characters both of the bodies and the extremities begin to be different. In the tailless apes the nails on the fingers are flat; and though the fingers are much longer in proportion than those of the hand, and the thumbs smaller and shorter, there is a slight resemblance; but when we come to the last of the order, the fingers are furnished with claws instead of nails, the thumb is reduced to a mere tubercle, against which the fingers act, the nose is more pointed, the animal does not live so exclusively by climbing among the branches; and the order ultimately verges in certain animals which are climbers, but which, in other respects, bear some resemblance to walking mammalia, and of these some are furnished with membranes or folds of the skin reaching from the fore feet to the hind ones, which they can spread out, and thereby protract their fall as they leap from branch to branch. But the animals of this order are so numerous, and the shades of specific difference among them are so many, that volumes would be required for even a very brief description of the whole. Generally speaking they are exclusively animals of the rich forest, useless and ill-adapted for any other situation; and if by any means, natural or artificial, those forests should disappear, no place would remain on earth for the four-handed animals; and thus all the memorials of them that could remain would be their bones in accumulated ruins over the surface, as we find to be the case with various races of animals, whose proper localities have been taken away in the lapse of years, and of which, though we sometimes find the bones in the ground, we never meet with one living specimen.

All the handed animals have the mammæ pectoral, and in some other parts of their organisation, as connected with the reproduction of the species, there are some external resemblances to the human subject, but as these also are connected with the growing system only, and not with the sentient, they have nothing to do with the intelligence and resources of the animal. Indeed the only inference that can be drawn from the situation of the mammæ upon the breast is, that the young ones can suck most safely and conveniently there. All climbing animals have them so situated, even the sloths; and surely they have not much resemblance to human beings!

CARNASSIER.

Animals of this order are still more numerous than handed animals; they are also more varied in their forms, adapted to more kinds of places, and much more generally distributed over the world. They are conveniently divided into families. *Cheiroptera*—winged hands—bats. These animals have their fingers greatly extended, and united by membranes, which extend to the hind feet, and in some of the species include the tail. Such is the tendency of the system of these animals to produce membrane, that many of them have the ears double, and appendages to the nose. Some few of them have the cheek teeth fitted for bruising vegetable substances: but the greater number have insectivorous teeth, and insects are the chief food of the family. They also eat various vegetable substances; but, notwithstanding all that has been said, it is still doubtful whether they suck the blood of sleepers, by first puncturing their feet. These animals feed at night, or at all events, in the twilight; their flying membranes do not take hold on the air, or rise through it with the same ease as the feathered wings of birds, and their flight is in consequence fluttering and ungraceful. They are found in many parts of the world, but most abundantly in warm countries, where caves, and ruined temples, and broken sepulchres, absolutely swarm with them. On these accounts they have been associated with gloom and superstition; and their popular history partakes of the mystery thence arising. Still, their numbers show that they perform an important duty in nature; and in the warm countries, especially, they are useful to man; for they not only destroy vast numbers of the noxious insects of the night, but, as they are very voracious, they consume many animal remains, which, if left to putrefy, would taint the air, and render it altogether injurious. Thus, when we divest ourselves of prejudice, and view the creature in conjunction with its use, we fail not to observe that creation still merits and enjoys the original benediction pronounced on it by its almighty Author, "God saw everything that he had made, and, behold, it was very good."

In some respects resembling the bat family, but differing from it in others, there is an animal known popularly by the name of the flying cat; but it has not the strongly supported shoulder joints, and the firm jointed elbows which enable the bats to work their flying membranes in the air, after the manner of wings; so that this animal, which is an inhabitant of trees, merely extends membranes between its feet to keep it up, when it leaps, as is the case with some of the squirrels and a few other animals; but it is quite incapable of making a stroke in the air, so as to gain a new impulse. This animal, as well as the bats, has the mammæ on the breast, while all the rest of the order have them on the belly.

Insectivora:—insect feeders. These animals have cheek teeth like the bats, but they are without membranes of flight, and very short on the legs, and slow in their motions. They are mostly nocturnal animals, and live in burrows dug by themselves, or other hiding places in the ground, so that they are seldom seen during the day. Like all insect feeders they are of great advantage to the cultivators of the ground; because those caterpillars and grubs which often so seriously destroy useful vegetables, are the young of those insects upon which animals of this description feed. Some of these animals are covered with spines, and roll themselves into a ball, as is the case with the hedgehog, and tenric. Others, as the shrews, golden moles, and musk rats, live in burrows; while the common moles live entirely under the ground. Those ground animals have generally the nose produced, and the feet short and very strong, while the eyes are exceedingly small, and in some species covered by a fold of the common skin, as is the case in several animals of the inferior classes. The star-nosed mole of North America has round the extremity of the snout a number of cartilaginous points resembling the rowel of a horseman's spur. These animals are very voracious in proportion to their size, and remarkable alike for their strength and their powers of endurance. The fur of those which live under ground is generally very beautiful, and that of the golden mole of southern Africa reflects almost all the colours of the rainbow, with a bright metallic lustre.

Carnivora. These are the characteristic animals of the order; as the ones which, more than any of the rest, kill other warm-blooded animals and feed on their flesh. There are great varieties among them; but they all possess, in a greater or less degree, those trenchant teeth which we have mentioned, as being the most unequivocal proof of the sanguinary disposition of an animal. Animals of this family are distributed through all parts of the world, some races more abundantly in the cold regions, and others in the warmer; they differ greatly in size and power, from the lion which can master a wild buffalo, to the smaller ones which can barely overcome a little bird or a mouse.

They are conveniently divided into two sections: those which are *plantigrada*, that is, walk on the whole soles of their feet; and *digitigrada*, that is, walk on the toes.

Plantigrada, are comparatively slow animals, generally nocturnal in their habits; and in cold countries passing the winter in a state of inactivity, and without food, which is also the case with the insectivorous family above mentioned. Those which pass the winter in this way are in the habit of accumulating much fat on their bodies before they retire to their winter repose; and this fat seems to be slowly taken up for the nourishment of the body during the time that they do not feed. It is a very general law among animals that those which have but scanty food during the winter accumulate fat before the winter sets in, which supports them during the season of scarcity. There are several animals which have particular parts of their body in which such accumulations take place, as, for instance, the hump on the back of a camel, or the dewlap between the forelegs of an ox. This section contains bears, badgers, gluttons, and various other animals, all of which are strong and durable for their size, and very voracious when food can be had; though most of them can endure want for a long time, and many can eat vegetable matter or insects when animal food is not to be had. The most insectivorous ones are understood to be those which dig burrows for themselves in the ground. All the division have five toes on each of their feet; and those toes, though they form a flat rather than a spreading foot, are generally armed. They differ in their predatory characters. The bears, for instance, have three insectivorous teeth in each side of the jaw, while the gluttons have only one; hence, though smaller in size, the gluttons are, in their general habits, much more sanguinary animals than the bears.

Digitigrada. These walk on the points of the toes, and are consequently more swift-footed, and therefore better able to hunt for their prey than the flat-footed animals. They are numerous, and include the most powerful and also the most sagacious of all the mammalia. They admit of farther separation into three subdivisions.

The first subdivision are, generally speaking, small animals; but they are exceedingly carnivorous, as is pointed out by their having only a single tuberculated tooth in the cheek, and all the others adapted for tearing flesh. They are very sanguinary animals; and, as their bodies are remarkably long and slender, they can follow their prey through very narrow places. Their feet are in general short; but they make some use of the elasticity of the spinal column for assisting them in their march. They are found, more or less, in most regions of the world; but they are most abundant in the cold countries of the north, where many of them pass the winter in a dormant state. Their skins are very strong, and the hair is firmly fixed and not easily spoiled, so that they are highly esteemed as furs; and an extensive trade is carried on for the capture of them in the northern parts, both of the eastern and western continents. Polecats, martens, otters, and a number of subdivisions of each, to which various names are given, and sometimes a summer name and a winter one when they change their colours with the seasons, are the chief animals of this division. Some of them can be tamed, but they never leave off their predatory habits, and become the companions or the willing servants of man.

The second subdivision are less carnivorous; and, of all the mammalia, some of them at least have the greatest number of resources. They have two tuberculous teeth behind the carnivorous one, and even that is not so trenchant as in many of the rest. Many of them are gregarious, and hunt in packs; and in a state of nature they either attack in large bodies, or proceed by craft more than by open daring; though the domesticated ones can be trained to display great courage, and to obey the instructions of man better than almost any other animals. The principal animals in this division are dogs, wolves, foxes, civets, and a few other, all of which have the general characters which we have stated, and also the surface of the tongue soft and smooth. The third and last subdivision have no small teeth behind the large cheek tooth in the lower jaw; and they are the most decidedly carnivorous of the whole order, though not more cruel than the animals forming the first subdivision. There are only two genera of them, hyænas and cats.

The mouth of the hyænas is very powerfully armed. They have three false grinders, or conical teeth, on each side, above and four below; and the upper carnivorous tooth is supported by a tubercle on the outside and one in front, against which the two trenchant points of the under tooth act. All those teeth are remarkably thick and strong; and the gnawing action of the cheek teeth of these animals is so very powerful that they can readily break the hardest bone. In their external form they bear some resemblance to the dogs; and they show a good deal of the disposition of these animals in being easily tamed, and showing a strong attachment to those who are kind to them. They have, however, the rough tongue of the cats, though not so much formed like a carving machine as in the larger animals of that genus. The hyæna, unless tamed, is restless in confinement; and hence the popular notion that it is untameable; but there have been instances of a hyæna recognising its former master after an absence of two years, and exhibiting as much delight at the discovery as any dog.

In the wild state these animals are nocturnal, exceedingly voracious, living upon carrion, and even invading the sepulchres of the dead. They are useful animals, however, in clearing the warm countries of putrid and offensive substances. They have only four toes on each of the feet; whereas the dogs have five toes on the fore feet, and four on the hind ones. The surikate of Africa, which in other respects belongs to the same division with the dogs, has also only four toes on each of the feet.

It appears that though the hyæna, in the existing species, is confined to Africa and the south of Asia, it has at some period of the world's history been much more generally distributed. In those caves of various parts of Germany, of some parts of England, and of other temperate or cold climates, where the bones of so many animals are accumulated, as that one would have supposed them to have been the established charnel-houses of large districts of country for many generations, the bones of hyænas are found among the rest, not in casual specimens, but as if they had been among the most common inhabitants of the locality. So numerous are they, indeed, in some of these places, that those who speculate beyond the facts on such matters, and it is not very easy always to refrain from so speculating, have supposed that some at least of these caves have been the dens of whole packs of hyænas, which collected there the bodies and spoils of other animals, and devoured them at their leisure. Be this as it may, it is certain that the remains of the animals are found in places where no living hyæna has been known naturally to dwell since the very earliest historical record. The progressive history of animals, and the changes which they and the countries in which they once inhabited have undergone in the lapse of ages, are, however, subjects of too extensive and too vague a nature to be introduced into a work like the present, the object of which is to take a rapid survey of what now exists.

The cats form the last genus of the carnivora, as inhabiting the land; and of the whole they are probably the most decided preyers upon living animals. Of all carnivorous mammalia, they are indeed the most perfectly organised for this purpose. There are no animals, in proportion to their size, so well armed for deeds of slaughter. Their muzzle is short and round, and their jaws also short, so that the muscles bring and hold them together with much greater force than in animals in which the jaws are longer. The claws on all their toes are sharp and crooked, and adapted for clutching and tearing; and when the animals walk these are drawn backward into sheaths and concealed between the toes, so that their sharp points are protected from external injury. The retraction is effected by means of elastic ligaments; and, as already mentioned, a different position of the limb causes the protrusion of the claws also by ligamentous elasticity. In all the species, the great muscular power of the animals is much concentrated on the fore-legs and the neck; and in the more formidable ones the difference between these and the posterior parts of the animal, in respect of muscular development, is very remarkable. In those larger species too, and partially, indeed, in all the species, the bones of the fore-legs are the most compact and heavy of any bones of which we are acquainted; so that besides the powerful clutch which they can take with the claws, the stroke of the paw is sufficient to fell a comparatively stout animal to the ground, and, indeed, to break its bones.

The teeth of those animals are peculiarly carnivorous. They have two false grinders above and below in each jaw; their great carnivorous tooth in the upper jaw has three trenchant lobes in the front, supported on the inside by a smooth heel; while the under one has two very sharp trenchant lobes, without any tubercle to stop its cutting motion. Their cheek teeth, not of a carnivorous character, are very few, being only one small one in each side of the upper jaw, and nothing in the under jaw at all corresponding to it. In consequence of this their jaws, formidable as they are, are by no means so well adapted for breaking and bruising as those of the hyæna, or even of the dog. This may be observed in the common cat, which finds a difficulty in endeavouring to break a small bone or gnaw any hard substance, which a dog of the smallest size could do with the greatest ease. Hence this race of animals are fitted for eating flesh much more than for gnawing the remains of animals from which the flesh is in part removed; but though they are not so capable of breaking bones with their jaws as the others, their tongues are adapted for scraping every particle of soft matter from the surface. They are beset with hard tubercles, which in the larger ones have the form of hooked teeth directed backwards, so that a smart application of the tongue would be sufficient to tear the skin of many animals in pieces.

The species of this genus are exceedingly numerous. The domestic cat may be considered the most gentle, and the gradation mounts upward until it closes with the lion and the tiger, which are the most formidable of all predatory animals. Those more powerful ones are confined to the wilds of the tropical countries, where prey for them is particularly abundant. The tiger is most formidable in India and the Indian islands, and is not found except in Southern Asia; while, on the other hand, Africa is the head-quarters of the lion, though it also occurs in India, and probably in some other parts of Asia. In America there are no animals of the genus nearly so formidable as those of the old continent. The puma, which is called the lion in South America, is not a very formidable animal, and seems to partake in part of the manners of the domestic cat. The jaguar, or American tiger, is more formidable, but still it is by no means equal to the tiger of the East. In the northern countries, animals of this genus are of smaller size, and covered with more lengthened fur in proportion to their size than in warm climates; but these evince, in proportion to their strength, an equally sanguinary disposition with their more formidable congeners of the South.

A great deal has been written respecting the differences of disposition of the more formidable animals of this genus, more especially the lion and the tiger. The lion has been described as the pattern of generosity and nobleness of disposition; while, on the other hand, the tiger has been branded as an animal devoted to blood and loving slaughter for its own sake. All such statements are contrary to the facts, and therefore they ought to be discarded from every work that professes to communicate rational instruction on the subject of natural history. The paws, the teeth, the digestive apparatus, and, indeed, the whole structure of every animal of that genus, point out that its very purpose in nature is that of killing other animals, and killing them in order that it may eat them. The impulse or propensity to this operation of killing, is the hunger of the animal, and nothing else; and when it has once satisfied this hunger it lays itself down in a state of quietude and repose, and disturbs no creature until it is again impelled by hunger.

Nor must we suppose that the very powerful armature of those animals, for the purposes of slaughter, is in any wise a fault or imperfection in the system of nature; for they are as necessary to the proper working of the system as those animals on which they feed. Nay, though at first sight it may seem a contradiction, the most immediate and direct good which they do is to those very animals which form their chief prey. In all nature, throughout the whole of its varied productions and forms, there is always an excess of productive power, which brings more of everything into existence than can so continue for its average natural period. This is part of that play of the system to which allusion was made in a former section, and which prevents the calamitous effects that would otherwise result from those changes which are continually taking place in the working of the system. It is not for the limited understanding of man to comprehend the whole, and to fathom the designs of Providence; but it is matter of observed truth that there are certain fluctuations of seasons, so that no year is in any country exactly like that which precedes or follows it. Upon this the plants and all vegetable-feeding animals are dependent; and therefore if there were not a surplus of productive power in them, they would never be able to make up the loss sustained during the unpropitious year; and the system of things would be thrown off its balance. But all the parts have a given elasticity; and, though we observe it not, there is no doubt that "the lion's share" goes to the general stock of those animals on which the lion preys whenever the balance of the system renders it necessary. In this way that animal, which we stigmatise as a destroyer, is in the accomplishment of the grand plan of creation really a preserver.

We have no means of getting experimental proof of this in wild nature; because whenever we interfere the system is changed, and made artificial to the full extent of our interference. But we know, from repeated observation, that when man takes possession, and regulates both the animals and the plants according to his artificial system, the lion, the tiger, and the other predatory animals, confess his dominion by fading away from the land. Thus, whithersoever we direct our contemplation through out the whole of nature's vast and varied field, we find the goodness and the preserving power of nature's Author and Governor equally manifest, and the fierceness of the lion and the gentleness of the lamb testify alike to the watchful providence of the Almighty Father of all.

Amphibia.—There remains yet one small group of animals, which, from their structure and mode of feeding, belong to the carnassiers rather than to any other part of the system; they are not numerous, and they are peculiar in some parts of their structure, as they inhabit the water and not the land; and consequently are adapted for motion through the former,—for swimming and not for walking.

These animals are the seals and the morses; of the first of which there are several species, differing from each other in some particulars; and of the second there is only one. In their general appearance these animals are intermediate between the land mammalia and the cetacea. The head and neck, especially in the seals, bear a considerable resemblance to the former, while the body is elongated into a swimming form. The fore-paws are confined within the skin as far as the elbow joints; and the feet, which are turned backwards and with the tail form a sort of swimming fin, are covered so far as the ankle joints. But both extremities have five toes armed with claws. All the cheek teeth are trenchant, and the animal feeds wholly upon fish, the common seal being very destructive of salmon when they come into the estuaries. The seal is a familiar and playful animal, and easily tamed. The morse is a larger animal; and its teeth are not so decidedly carnivorous as those of the seal; but its digestive apparatus is very similar. Two large tusks, which project downward from the upper jaw, give it a singular appearance, which is increased by a quantity of hair on the upper lip. Seals are very abundant, and much sought after for their oil and their skins. Morses are not so abundant; and they are almost confined to the polar seas. Though these animals are called amphibia, which means living in both, they are not equally adapted for the land and the water. They feed in the water; but they rise to the surface in order to breathe the free air. Indeed there is no warm-blooded animal which can breathe under the water, that mode of breathing being applicable to gills only, and not to lungs.

RODENTIA.

These form the fifth order of mammalia. Their principal character is that of the teeth, which are peculiar and well defined, quite distinct in their arrangement and appearance from those of any other order of animals. Their incisive teeth, generally two in each jaw, are so formed that the two jaws act like a pair of cutting pincers. In this way some of them can bite severely; but their teeth are not in any way adapted for killing other animals, or for tearing flesh. They are all systematically vegetable feeders; and the name rodentia, which literally signifies "gnawing teeth," is derived from the Latin word *rodo*, "I gnaw." They are formed for subsisting on hard vegetable substances, which call their gnawing powers into action. Many of them live upon bark, and even upon woody fibre, and they all have the power of cutting through hard vegetable matter with more success than even other animals which are possessed of greater strength, and have their mouths armed with more formidable apparatus. To adapt them for this purpose, their front or cutting-teeth have, as has already been hinted, none of the enamel, or hard substance which forms the cutting part of a tooth, anywhere but on their external surfaces; and as those teeth necessarily wear away in consequence of the severe labour which they have to perform, they continue growing during the lives of the animals; and if any of them happen to be broken or destroyed in any way, so as that the opposite one can have nothing that it can act against in the operation of gnawing, that opposite one increases to a vast length, and renders the mouth of the animal very unfit for its proper function. The lower jaw is articulated upon elongated condyles, so that it does not admit of lateral motion, as is the case with the human jaws, and those of all animals which grind their food. The fore teeth of the rodent animals cut their food into small portions, as if it were pinched off with nippers; and the cheek teeth, which are nearly all on the same level, but have their crowns interspersed with ridges of enamel supported by softer bone, are adapted only for bruising the food thus prepared, and not for grinding it. There are some, however, which have the cheek teeth with a greater or smaller number of sharp points; and those which have teeth of this description are partial to animal substances, and sometimes prey upon weak animals, thus taking up the succession where the carnivorous animals, properly so called, leave it off. In general these animals have the stomach simple, or very little divided by partitions, the intestinal canal very long, and the cæcal appendage to it very large. In one genus, however, the dormouse, this appendage to the canal is wanting. In the whole order, the brain is smooth and simple, and without any convolutions, and true to this character, the animals have generally speaking fewer resources than those of the orders previously noticed. The orbits of the eyes are not separated from the temporal fosses, and the shallowness of these shows that the animals have small muscles to the jaws, and therefore inferior power in the closing of them. In consequence of this they perform their labour more by a series of gnawing than by a decided bite. The greater number have the fore extremities much more feeble than the hind ones; and in many there are no distinct clavicles, and the fore paws are incapable of acting in the cross direction. In others, however the clavicles are more perfect; and in some the fore paws can be brought to the mouth so as to assist the animals in feeding, while in one genus, the aye-aye of the African islands, there is a slight approach to the handed animals.

Animals of this order are found in almost every region of the world. Some of them live habitually in trees, and are expert climbers; others conceal themselves among the thick herbage at the roots of trees; others again live in the open fields; and others still live in holes of walls, or of the earth, or dig themselves burrows. Several of those which are inhabitants of cold latitudes, or countries near the perpetual snow upon the mountains, pass the winter in a dormant state; while others are active at all seasons.

In general they are timid animals, and avoid the sight of man; and their skins and fur are generally of weaker texture than those of carnivorous animals. Some of them are, however, remarkable for the delicate textnre of their coats; and their skins are on this account highly valued as furs. The larger ones are much sought after as human food; and it is probable that the whole family have wholesome flesh, though some are too small for being of much value, and others have got a bad name from the depredations which they commit. The mice and rats which infest houses are of this latter description; and so are some of the field ones which often invade the cultivated parts of the country as thick as locusts.

Animals which, like these, are found in every region of the world, whether cold or warm, and whatever may be the character of its surface and productions, are necessarily much diversified both in their appearance and their manners. Even in

Australia, where, as we have already hinted, the native mammalia are marsupial, and not placential for the whole period of gestation, as they are in most other parts of the world, there are many of the marsupial animals which more nearly resemble the rodentia than they do any other order of common mammalia. Even the kangaroo has more resemblance to our hares and rabbits, than it has to other animals with which it more nearly corresponds in size.

Animals of this order are in many, indeed in most of the genera, remarkable for their fecundity; the number of their litters is often considerable, and the period of their gestation is short. When we consider these things, and bear in mind that no power has been given in vain by the Creator, we cannot but perceive that those rodent animals have a very essential office to perform in vital nature; and taking them in all their races, and in the endless variety of stations which they occupy, they may probably be considered as above all others the trimmers and dressers of the vegetable kingdom in wild nature. The handed animals which live in trees, eat fruits. Some which remain yet to be described eat leaves in their green and succulent state; and others again dig up the succulent roots of plants from the earth. But though at certain seasons the rodent animals also consume green or growing vegetable matter, yet their proper province appears to be to consume those vegetable substances which are in a state of incipient decay, or the surplus of the harder fruits and seeds, which would choke each other if all left to germinate.

The genera and species are so exceedingly numerous that it would require many volumes to give a full enumeration of them, we must therefore content ourselves with merely mentioning one or two of the most remarkable.

The squirrels are the most numerous, and most characteristic of those species which climb trees, and, in great part at least, subsist upon fruits. The common squirrel is well known as an inhabitant of different woods in this country; and though there are many species and varieties, there is a strong family likeness which runs throughout the whole. They have the lower incisive teeth much compressed; the tail very long and covered with hair, which projects laterally, something like the webs of a quill. They have four toes on the fore-feet, and five on the hind ones; but the fore-thumb is often indicated by a little knob or tubercle. Their eyes are brilliant and lively, and stand out from the sides of the head. Indeed the whole order, or at all events the major part of them, are remarkable for prominent eyes, and the consequent range of their vision. They are lively and playful animals, capable of leaping to great distances; and some of them have the skin of the sides produced in such a manner as that they can extend it by stretching the legs, and thus protract their fall; but though these are called flying squirrels, they cannot fly, that is, they cannot give themselves a new impulse in the air, or leap from anything but a solid support. Squirrels are found in almost every part of the world; they live in the forests, and, generally speaking, are perfectly harmless to man, though in some countries, especially where there are nut-bearing palms, they commit considerable depredations upon the fruit of these.

Closely connected with the squirrel is the aye-

aye above alluded to, Of this there is but one species, having the lower incisors very much compressed, and five toes on all the feet, of which the front ones are exceedingly long, and though they slightly resemble hands, they are fully as like the toes of a bird and have long and crooked claws, not unlike birds' claws.

Rats and mice, divided into many genera and subgenera, form an extensive portion of this order; so extensive indeed, and so diversified, that among the smaller species, it is not very easy to say positively what is a rat or mouse, or what is not. The greater part, if not the whole, of this family live in holes of the ground; and there is scarcely an imaginable surface upon the earth affording subsistence to a vegetable-feeding animal, in which one species or other is not found. We have field-rats, meadow-rats, water-rats; and in short rats and mice, for the difference between them is chiefly difference of size, named after every kind of country that can be imagined. Many of these collect magazines of provisions against the winter; and some of them, as, for instance, the lemming of the Scandinavian mountains, descend in such numbers at particular seasons, as to consume everything on the surface of the earth, while they themselves are followed and fed upon by numerous birds of prey. Many of these animals have the hair on some parts of the body at least, not round in the section, but flattened and enlarged in the form of spines. Those which have this curious covering on the back are chiefly natives of South America, in which we find animals of other orders, of which the coverings are still more curious. The marmot and the dormouse are remarkable for the state of profound hybernation in which they pass the winter.

The jerboas, and numerous other races, some of which inhabit only warm countries, are also dormant during the winter.

Our most characteristic species, or, at all events, our most valuable ones in this country, are hares and rabbits; and our most troublesome ones are mice and rats, especially the large brown rat, which takes possession of common sewers, and other subterranean passages in great cities, and which is of no inconsiderable use as a scavenger, though very dexterous in gnawing timber, and boring into the earth. The most singular in its manners, and in some respects the most useful to mankind, of all these animals is the beaver. Some of the accounts of this creature are much exaggerated; but still its building propensities are truly wonderful, and they are sufficient to show by what simple means nature can accomplish the most curious ends. Beavers were once natives of the British islands, and there are still a few in some parts of Germany; but they are more numerous in the unfrequented parts of the Russian dominions, and especially in the northern parts of America. They are gregarious animals; though each pair or family are understood to be solitary in their labours. They generally choose such waters as are not frozen to the bottom in the winter; they construct regulating dams by which the water is preserved at a uniform height; and they form houses of stone, sticks, and mud, something in the shape of beehives. They have always an outlet to the water from their habitations; and they collect a store of provisions for the winter, which consist principally of small branches of trees; but they can, by continued labour, cut a branch of considerable thickness; and contrive to move a large lump of wood through water, or a tolerably big one on land. They are gentle and inoffensive animals, and can be tamed without much difficulty; and it is said that in this state they will eat animal substances. It is in winter only that those animals assemble in their villages and huts; for during the summer, they disperse themselves over the country, and do not form habitations. The fine or under fur of the beaver is more prized than that of almost any other animal for the manufacture of hats, as it is fine in the texture, felts well, and retains its dye. Beavers which have been kept in zoological gardens in this country, have lived chiefly in the water; but they seasonally showed their building propensities by carrying sticks, and examining the huts erected for them, as if to see whether they were in good order.

The porcupines form another singular genus of animals of this order; and they are at once known by the long and hard spines with which their bodies are armed, in which respect they bear some resemblance to the hedgehogs. But the porcupines are true rodentia, perfectly harmless to all other animals, living only upon vegetable matter, burrowing in the ground, and having, indeed, many of the habits of rabbits. The common porcupine, which is found in the south of Europe, and the north of Africa and Asia, is about the size of a hare. A still more curious one, inhabiting the warm parts of America, has the tail prehensile, so that it can suspend itself from the branches of trees by clasping them with that organ. Some of the Indian species have the spines flattened; and there are some in North America with the spines so short, and the hair so long, that the former are not seen. It would, however, be almost endless to point out the distinctions of this very generally distributed and exceedingly numerous order of animals. Their chief use in the economy of nature seems, as has been said, to be clearing the earth of vegetable waste, in the same manner as those animals which eat carrion clear it of animal waste; and among genera which are so numerous, and differ so much in their localities, and consequently in their food, we may be prepared to meet with considerable diversities of habit; as, for example, that one part of the order shall make a slight approach to carnivorous animals on the one hand, and that another shall, on the other hand, make a slight approach to those animals which feed on green and succulent vegetation.

We must still further remark of these animals, that they are found in vast numbers in situations where it is not very easy to see how so many animals, and those too, at least for certain periods of the year, hearty feeders, can subsist. We have already alluded to the immense hordes of rats which tenant the shores and drains in cities. Rabbit warrens are generally in places of a dry and sandy character, where vegetation is but scanty; and many of the foreign races, such as the chinchilla family in South America, and some resembling these in habits, though not in appearance, are found in vast multitudes in parts of the country which are almost desert, and where, for great part of the year at least, they can have no subsistence except the dry and withered stems of the seasonal vegetation which appears in such places along with the rains, but disappears during the drought.

EDENTATA.

The animals of this order are by no means so numerous as those of the former, neither is their general character, or their place and use in the system of nature, so well made out. This might be expected from the fact that the character from which they are named is a negative and not a positive one.

Edentata, or toothless, is not a correct name for these animals, because it applies in its full extent to one genus only. The others have cheek teeth, though generally of a peculiar form; and some species have incisive teeth. They are, in fact, very peculiar animals, differing greatly from each other, as well as from all the rest of the mammalia; and therefore it is exceedingly difficult to find any name or character which will apply to the whole.

The genera are not numerous; and in a living state they are confined to very peculiar regions of the world. South America is their head quarters, where the most remarkable and the most characteristic species are found. There are also some in Southern Africa, and in the south east of Asia, which differ much from the American ones; and there are some analogous species of marsupial animals in Australia, which, in so far as the characters of their mouths are concerned, are true edentata; but they fall in more properly with the marsupial division, though, in some respects, they differ from all known mammalia.

As those animals are few in number, and characteristic of countries differing greatly from Europe, we may give a brief notice of them :—

First, there are the sloths, or slow walkers (tardigrada), of which there are two living species, and perhaps some varieties, at least in colours ; and one species of much more ample dimensions than those which exist, but of which the only memorials are bones buried in the earth. This extinct species appears to have been of the most gigantic dimensions. An entire skeleton has been met with at a considerable depth in the soil in the valley of La Plata ; the length of this one appears to have been upwards of twelve feet ; and the height between seven and eight ; this is not the average measure of an elephant, but still we must not judge from dimensions alone ; for the skeleton of this animal is so massive, that the elephant's bones beside it appear a mere assemblage of reeds. On this account the animal has been called *megatherium* which means "great beast ;" and if its quantity of flesh bore the same proportion to the size of its bones, as is usual in animals, it must have been well worthy of the name. The last phalange, or joint of the toes, contains at least as much bone for the larger toe on the fore foot as there is in the whole human body. The structure of the feet shows that the animal could not have walked excepting at the slowest pace and with the greatest difficulty ; and the vast projection and peculiar form of the processes on the spine, and of various other productions of the bones, show that it must have carried a vast load of flesh. Its teeth, which bear at least a slight resemblance to the cheek teeth of the elephant, point out that it must have fed upon boughs, and other hard vegetable substances, and not been in the least degree carnivorous, or disposed to injure any other animal. From the close resemblance which there is between the bones of the legs of this animal and those of the common sloths, we would naturally conclude that its habits must have been similar to theirs, namely, that it must have lived in trees, and fed upon the leaves and branches, hanging suspended with its back undermost. The common sloths are about the size of cats, and the megatherium must have been at least as weighty as an elephant; the forests which the sloths inhabit contain giant trees in our estimation, what then must have been the character of those forests among the twigs and branches of which this giant animal moved about as lightly and securely as squirrels do in the branches of our oaks? The times when this animal lived must, however, be long gone by, for the bones are met with at the depth of a hundred feet under the surface, and it must have required the floods of many seasons of rain before this depth of mud was deposited.

The common sloths, though of but small dimensions, are curious animals, adapted for one locality and one mode of life only. Their hind feet are much smaller, or at all events shorter, than their fore ones, and they are articulated something in the same way as those of the handed animals which are the most expert climbers. In consequence of this, the side of the hind foot and part of the leg come in contact with the ground, and the animal cannot walk but with the greatest difficulty. The toes, which are two on the fore feet of the one and three on those of the other, are united together so as to form one single piece, and leave no division of the foot except the claws, which are long and crooked, and remain bent like hooks by the action of ligaments, except when the animal stretches them out by muscular exertion, which to it appears a slow and painful operation.

From this structure the animal is utterly helpless on the ground; but among the branches of a tree, where it catches by the feet, and suspends itself without the least exertion or fatigue, this animal is as completely at home, and as beautifully adapted to its place in nature, as the fleetest animal which sports in the meadow or bounds over the heath.

The sloth is a grazing animal in some sort though it does not actually ruminate. It is wholly without fore teeth or canines; and thus it can neither bite nor gnaw, so that the large leaves, with which trees in tropical forests are in general furnished, serve it for food; and it, so to speak, grazes the green leaves of the trees, with its back undermost, and its feet against the sky. Thus its legs are a sort of supporting chains and not supporting props; and, therefore, when they come to be used as props it is contrary to their nature, and they do not apply.

There is something farther which is worthy of consideration in the structure of this singular animal. In all animals whose general habit is an upright position on the legs, and which use those legs for moderately rapid motion along the ground, the arteries which supply the legs with blood come off in large trunks, and gradually divide into ramifications as they reach the extremity of the member;

but in the sloth, and in some of those apes, monkeys, and other animals of that order which are the best climbers and the worst walkers, the arteries which supply the limbs with blood come off in a number of small branches, which branches again unite to form the principal artery of the limb. This structure renders the circulation in the limbs much slower than that in the body; and as both the energy and the exhaustion of an animal, or part of an animal, are in proportion to the rapidity of the circulation, the legs of the sloth, though moved with extreme slowness, may be regarded as possessing greater powers of endurance than any other organs among vertebrated animals. It appears also that the animals themselves are patient of hunger, and can endure long without food, which often begins to fail them toward the close of the dry season, when the air is still and the sun beats strongly through the naked twigs from which the sloths have eaten the leaves.

But when the season turns, and after the lightning has given its sign and the thunder sounded its trumpet, which are bright and loud in those lands where the working of the Almighty is shown upon the most splendid scale, and the winds rock the forest to its foundations, the sloths are aroused into more than wonted activity: the gusts of wind bring into contact trees which ere while stood apart; and thus the sloths take advantage of the storm in order to disperse themselves to new pastures, where they may live in plenty and rear their progeny in peace. The female sloths have two pectoral mammæ; they bring forth but one young one at a time, which remains clasping the body of its mother with the same firm yet passive hold as she clasps the branches of the trees.

Those who go to the study of nature with preconceived notions respecting standards of beauty, and who thereby blind their own eyes so as to be incapable of discerning that the wisdom of God is equally perfect in all his works, have affected to make merry at the ungainly form and shaggy covering of those animals; but truly the only jest is the folly of man (man is nature's only fool); for, studied in combination with the circumstances under which they exist, there is not a more beautiful instance of structural adaptation than we find in those sloths; and we may add that the same bounty has provided them more securely against the contingency of falling from the trees; for the flesh on their backs is so much accumulated, and the hair so thick and matted, that a sloth might fall from the top of the highest tree without receiving any material injury. The covering of their bodies differs in texture from the hair of most animals; it is dry, bearing some resemblance to fibres of whalebone, and appears to be much less sensible to changes of the weather than that of animals which live on the ground. That the tropical forests are gradually decaying and the race of such animals as the sloth fast wearing out, seem probable: and when we consider that their giant congener, to which we have alluded, is now more deeply buried in the earth than they are raised above its surface, we cannot fail in regarding the sloths with increased interest.

The armadillos (dasypus) form the next genus of this order of animals. They are exactly the reverse of the sloths; being ground animals, all of them insectivorous, and some at least absolutely carnivorous, digging into and eating the carcasses of slain beasts (for in their country beasts are so numerous that they are often slain for the skins only), and also digging into the graves of the dead. They are all South American animals, some of them are numerous although rarely seen in proportion to their numbers; and they form a singular feature in the ground mammalia of South America, as the sloths do among those which inhabit trees.

None of the armadillos have canine teeth; and in general they have no incisors, some, however, have two in the upper jaw and four in the under; while the cheek teeth, in the different species, vary from twenty-eight to sixty-eight. These teeth are cylindrical, stand apart from each other, and have no enamel on their inner sides. The head is elongated, the mouth small, and the tongue capable of partial extension beyond the mouth, indicating an insectivorous habit. The legs are short but stoutly made, with five toes on the hind feet and four or five on the fore, which are furnished with long nails, well adapted for digging. In some the females have only two mammæ, but in others they have four, though the number of their broods is often greater than that. The most remarkable external character of these animals is the covering of their bodies, which consists of a strong coat of mail of a consistency intermediate between horn and bone, and exceedingly hard. This descends a good way on the legs, and consists of a greater or smaller number of jointed plates, which are not always constant even in the same species; and it is quite impenetrable by the teeth of any predatory animal. Their tails are long and in general covered with rings of matter similar to the shield on the back. They live in the woods and wastes, feeding indiscriminately on the succulent bulbs and plants, for which they burrow in the ground, and on insects and the bodies of dead animals; though some of them at least eat the eggs and young of ground birds, and are capable of killing small animals. In their native country most of them live in comparative concealment, and several species come abroad and feed only during the night; but notwithstanding the heavy armour with which their bodies are covered, they are often very quick and restless in their motions; and some, which have been kept alive in zoological gardens in Europe, have been very prone to kill rabbits, guinea pigs, and other small ruminant mammalia. There are few animals so well adapted for burrowing in the earth as those armadillos, and they are altogether a very curious race. In general they have a musky smell, which is possessed by many of the ground animals of South America; but some of the species, when roasted in their own shells, are reckoned very delicious eating.

A very curious animal, agreeing with these in the form of its feet, and some other of its habits, but differing in the shape and colour of its body, is the orycteropus (digging foot) of Southern Africa, which is called the ground hog in that country. It is about the size of a badger, very low on the legs, and covered with coarse greyish hair, which is very thinly scattered over its body and tail. The nose is produced and truncated at the extremity, something like that of a pig. The ears are large; there are no incisors or canine teeth, but six cheek teeth in both sides of each jaw. The fore feet have four toes, and the hind feet five; the crowns of which consist of a number of little pipes of enamel filled up with bone; the nails on the toes are flattened and well adapted for digging. It lives in the earth during the day, but sallies forth at night to the ant-hills, where, making a breach with its foot, it speedily collects a number of those active little creatures on its protrusile tongue, which is furnished with a gluey secretion, and thus, small as its prey are individually, it draws them into its mouth by hundreds, and thus contrives to make a hearty meal.

It is worthy of remark, that, while this animal, which, on the eastern continent, bears the greatest resemblance to the armadillos of the west, is covered with hair, while they are clad in armour, the ant eaters of the west should be furnished with hair, while those of the east are coated with scales.

The ant eaters, properly so called, are natives of South America only. They are covered with long hair, have a large muzzle and small mouth, without any teeth, with a slender tongue covered with a viscid secretion, and capable of being protruded a considerable way from the mouth. The nails on the fore feet are very strong, and with these they tear large openings in the nests of those ground insects which live in crowded colonies, and as the insects come out they are caught in multitudes by the viscid matter on the tongue. There are three or four species, varying from upwards of four feet in length to a size not bigger than a common rat. The largest ones live on the ground only, and are very slow walkers; but the smaller ones climb trees, in which operation they are assisted by the tail, which is naked toward the extremity, and capable of laying hold.

The allied race are usually termed pangolins. They belong exclusively to the eastern world, and occupy the same place in nature there, as the hairy ant eaters do in South America. Like these they are confined to the wooded districts in the very warmest latitudes, where ground insects living in colonies are found in immense numbers. They have no teeth, but their tongue is very protrusile; and their bodies, their limbs, and their tails, are covered with thick scales, which are placed over each other, something like tiles on a roof. When attacked, these animals can roll themselves up in the form of a ball, by bringing the tail across the under part of the body and over the head; and when they assume this form their scales stand out so much and are so strong and sharp, that they form complete defences against beasts of prey. They are found in the south-east of Asia and the eastern islands, and also in tropical Africa; and the chief distinction between them is, that the Asiatic ones have the tail rather short, and the African ones have it very long.

Those singular animals have an important part to perform in the economy of nature in tropical climates. Wherever such climates yield a sufficient supply of moisture, the growth both of plants and of trees is rapid beyond what we of temperate climates have any conception of. It is a law of nature, that decay keeps pace with production; and, according to this law, the tropical forests would soon be encumbered with dead wood, and other decaying vegetable matter, which would choke and destroy all living vegetation, if some means were not provided for its removal. This labour devolves upon the insect races, upon the termites, usually called white ants, and several others, the production of which is rapid, and their numbers great beyond all imagination. These myriads feed almost exclusively upon timber; and in brief space reduce the trunk of a large tree to powder, which operation they commence as soon as the tree dies and becomes sapless. In this way they prevent the accumulation of rotten wood, which would destroy the vegetative power of the earth; and thus while tree succeeds tree with the full maximum of rapidity and luxuriance, the forest is not rendered foul by the remains of the dead. These scavengers of the tropical forest require a regulating power to be set over them; because it is a law throughout all the works of nature, that the means of regulation are always in exact proportion to the energy to that which they regulate. Hence the use of the different species of ant-eaters, which have also many races of birds that assist them in regulating with that perfect wisdom and equity which characterise all the laws of nature, those insects in which the power of production is so exceedingly vigorous.

The other animals, namely, those of New Holland, which are usually included in this order, are, as we have said, marsupial, and can therefore be noticed with more propriety among the others which have that structure.

PACHYDERMATA.

This is also rather a loose character; and the animals which are arranged into this order are, like those in that immediately preceding, different from each other. They have, however, certain characters in common besides the thickness of the skin. In them the feet cease to be in any way organs of prehension, that is, they are quite incapable of grasping, and are merely walking feet. In general the animals are without clavicles or collar bones, so that they cannot use their fore legs in any sort of cross motion, as in holding any substance between them or in bringing them to the mouth, though some of them can use the foot as a point of rest while the mouth or its appendages are applied to the substance so held. As the races of mammalia now stand, some of the pachydermata are the largest of the whole; none of them are naturally carnivorous, as neither their feet nor their mouths are adapted for this purpose; but there are some which are rather miscellaneous in their feeding.

They are usually formed into three sections; those with an elongated proboscis which they can use as a prehensile instrument; those which have no very distinct common character except that of having thick skins; and those which have the feet included at their extremities in a single hoof.

The first section consists of the elephants, which are now so well known as not to require a detailed description. There are two distinct species, either original or climatal, namely, the elephant of Asia, and the elephant of Africa. The former is the larger and more gentle animal of the two, and it is the only one which man has hitherto pressed into his service as a labourer; but though in a state of confinement it shows attachment and docility, and (though many of the accounts are greatly exaggerated) is by no means destitute of animal sagacity, it cannot be said to be domesticated, so as to have become a dweller with man. Elephants do breed in confinement; but this is a rare occurrence; and almost the whole of those which are procured for labour or display, are taken from the herds which range the damp forests in a state of wild nature. The principal places haunted by this Asiatic species, are the damp countries immediately to the north-east of the Bay of Bengal, and the richer districts of the Indian Archipelago, where they are said to be rather smaller than on the continent, but more energetic in proportion to their size, and, therefore, less easily broken to obedience.

In a state of nature, those stately animals live in their close and damp forests at comparative peace with every living creature. They feed upon the tall reeds and the grasses, on the boughs of trees, and, generally speaking, upon all vegetable substances. When cultivated fields, especially those of sugar canes, are situated near the woods in which the elephants reside, the animals often sally forth and commit great depredations upon them; but in general they live in the retirement of the forest.

The African elephant is, as we have said, smaller in size than the Indian one; and its expression is not so sagacious. Its forehead is rounded, its head altogether shorter, and its tusks proportionally longer. Its ears also are much larger, and it is a different looking animal in various other particulars.

The tusks of elephants, which form the substance called ivory, are the incisors; and they are of no use to the animal as teeth, though they are, in some cases, as defensive weapons. The other teeth are adapted only for cutting and bruising vegetables; and, as they wear away by the great labour required in the support of so large an animal, they are supplied by others from behind, which push forward their predecessors; and thus the efficient part of the mouth, as a feeding instrument, is to repair itself during the whole life of the animal. In the Asiatic species the tusks of the female are generally much smaller than those of the male, while in the African they are nearly the same.

The toes of elephants are more perfect in the skeleton than those of any others of the order; but they are so cased up in the thick covering of the foot that scarcely anything but the nails is discernible; and of these nails the African species have only three on the hind feet.

Owing, perhaps, to its great size, and its singular form, the sagacity of the elephant has been ridiculously exaggerated; and, if we were to credit even half the accounts which are given of it, we should be inclined to rank it the foremost of all the mammalia in this respect. This, however, is a mistake; and there is not in the elephant any violation of the general law which runs through the whole of the animal world, that the sagacity, as we call it, of animals is in proportion to the general development of their sentient structure; and that this again is in proportion to the contingencies and vicissitudes to which the animal is exposed.

Now the existing species of elephants are all in a state of nature, not only animals of peculiar and comparatively confined localities, but animals of localities in which, with a moderate range in pasturing not exceeding that of the heavier ruminant animals which inhabit the moist meadows near the waters, they can find food in abundance all the year round. Those elephants, therefore, in their natural state, have less use for what is called animal sagacity, than animals which are thrown more upon their shifts; and it would be contrary to the general system and law of nature that they should possess a degree of this sagacity, which their proper place in nature does not require. The fact corresponds; for, notwithstanding all that has been said and written concerning it, the boasted sagacity of the elephant is inferior, not only in degree, but absolutely almost in kind, to that of the dog.

What may have been the state of things when elephants (or animals closely approaching to elephants in their size and structure) were more generally distributed, and reached even the extreme north of the world, it is impossible for us to say; because comparative anatomy has not yet become so perfect a science as that we can with certainty infer the dispositions of an animal from the structure of its bones. But in many parts of the northern climates, in several parts of Europe, and especially in the north of Siberia, the skeletons of elephants have been found in great abundance buried in the earth; and, in more instances than one, the entire animal has been found preserved in a vast block of ice. In many parts of their structure those lost elephants bear a great resemblance to the species now existing; and though their tusks are generally more crooked than those of the southern ones, they appear to have had a very similar position. In their covering, those northern animals appear to have differed greatly from their congeners of the south, and to have been especially provided against heavy falls of snow and extreme cold. The southern elephants have very little hair on the body generally; but the northern ones had it abundantly, and of two kinds, as is very common in animals which have to bear severe climates. The longest hair appears to have been of a black colour, and formed of large bristles as thick as a common rush, especially upon the neck or mane of the animal; while among the roots of those bristles there was a thick coat of frizzly or woolly hair, of a brown colour, and calculated to form warm clothing for the owner.

There are several other fossil species of animals which must have been more or less furnished with prehensile trunks, and therefore bore some resemblance to the elephants in their habits, the remains of which are found in Asia and Europe, and still more abundantly in North America; but none of these have been met with in so perfect a state as the northern elephants, and therefore our knowledge of them is not so precise. The investigation of this subject is very interesting; but it would lead us to an extent quite incompatible with the object of this compendium, which is chiefly to show the economy and laws of the works of creation, as they now are in living or active existence.

After the elephants, follow that family which are usually styled the ordinary pachydermata, which have four, three, or two toes on the feet. In those which have two toes, or what is usually termed a divided hoof, there is a slight approach to the ruminating animals, not only in the structure of the skeleton, but in the stomach. Of these animals, the least deviation from the elephant is perhaps found in the hippopotamus, which is a large animal inhabiting the rivers of most parts of Africa. These animals have an unwieldly body, without hair, very short legs, with four hoofed toes on each, the belly almost touching the ground, the head large, the muzzle broad, all the three kinds of teeth, of which the canines are very large, the tail short, and the eyes and ears very small. They live on roots and other aquatic vegetables which they tear up with their great canine teeth. Left undisturbed, they are inoffensive, though dull and stupid; but they are very ferocious when attacked. We are not aware that even the most powerful carnivorous animal ventures to assail the hippopotamus.

The hog family come next, of which the characters are well known, from the domestic animal with which every one is familiar. The babyroussa of India has the tusks peculiar, as those of the upper jaw rise through the bone above, and are curled backwards. The African hogs have most formidable tusks, and large fleshy appendages hanging from their cheeks; the peccaries have no projecting tusks, and they have the fore-feet with four toes, and the hind with three; they are gentle animals, and inhabit the American continent. The tapirs inhabit the same continent, and have the feet of the same form; but the nose is produced into a sort of proboscis, moveable, but not prehensile like those of the elephants. The American tapir is all over brown, and is rather a large animal, being six feet long, and above five feet in height; and there is also a species belonging to the south of Asia, which is larger than the American, and has the back brownish white. In their habits, and also in the qualities of their flesh, these animals bear a considerable resemblance to the common hog, and the whole of them feed chiefly upon vegetable matter.

The rhinoceros is one of the most powerful animals of this order: its body is remarkably thick, and covered with a folded skin; its legs are short, and each terminates in three toes. It is a dull but ferocious animal, inhabiting very moist places, and living upon the branches of trees, reeds, and other vegetable matters. The most remarkable external character of this animal is an appendage on the nose, which is usually called the horn, but which differs from everything else in animals to which that name is given. Is grows from the skin only, without any core of bone, or without any of that cellular structure which is observed in the horns of deer. Whalebone, or a number of hairs firmly soldered together, resembles most nearly the texture of this singular appendage. The animal can, however, use it as a most formidable weapon. There are two species of this genus, and some varieties; those of Asia have generally one horn upon the nose, and those of Africa have two. When the rhinoceros is kept in a state of confinement it often grinds his horn down to a mere stump by rubbing it against its den; but if properly fed, though a dull and sluggish, it is not a vicious animal.

All the pachydermata hitherto noticed are partial to humid grounds; and many of them wallow in the mire and the mud, while most live close by the margins of waters and some, as the hippopotamus, make the fresh waters their principal dwelling. The animals are so different in their general structure, and so many of them belong to races which have now vanished from the living world, that there is some difficulty in assigning them their proper place, and pointing out their use in the economy of nature. Still they are curious animals, and connect themselves with the natural history of curious and peculiar places.

The last family of the pachydermata comprehends those which have entire hoofs to the feet—the horse, the ass, the zebra, and one or two others. The horse is not anywhere known in what can be considered as positively a state of nature; for from the number of wild horses which are now met with in south America, where there was no animal of this family previous to the settlement of the country by Europeans, it is impossible to say that those wild horses which are met with in some parts of the East are not the descendants of some race which has once been in subjection to man.

These solid-footed animals differ from all the pachydermata in inhabiting dry situations only when they are in a state of nature, or approaching to it. They are all social animals in a state of nature; and the docility of the horse and patient labours of the ass are familiar to a proverb. The zebra is, however, a more stubborn animal, and has hitherto been unbroken to the rein or the yoke; but the variety of its colours gives it a good deal of interest as an ornamental animal.

RUMINANTIA.

The whole of this order use the feet for walking only; and they are all vegetable feeders, generally speaking consumers of the green herbage of the earth, though when that fails they eat dried stalks and leaves. The structure of their mouths is peculiar; they have incisive teeth in the lower jaw only, where there are usually eight; and these act against a callous or insensible portion of the upper jaw. Most species have no canine teeth in either jaw; but some have them in the upper jaw, and a few have them in both. The cheek teeth are always six on each side of both jaws, with flat crowns furrowed like millstones; and the jaws have a lateral or grinding motion. They have no clavicles, and thus the feet are not adapted for any action except walking. The metacarpal and metatarsal bones are single; each foot terminates in two toes armed with hoofs; and behind those proper hoofs there are often rudimental toes with smaller hoofs, which, however, do not reach the ground in walking. The united bones of the metatarsus and metacarpus are technically known by the name of the canon-bones; and there are a few species in which a second bone is partially produced.

Some animals of this order have the heads without any appendage; but the males in the greater number, and both males and females in some, are furnished with horny appendages of different forms, which are peculiar to this order of animals, for the hard projections from the mouths and heads of many of the pachydermata are tusks, while that which is called a horn on the rhinoceros is merely a production of the skin, and not connected with the bone of the animal.

These horns of the ruminantia differ a good deal in the several groups or families of which the order is composed. They are wanting altogether in the camel family; and these also differ from all the others in the structure of their feet, the soles of which are covered with elastic pads, and they have only broad nails on the upper parts of the toes, and not real hoofs embracing the whole extremity of these members.

The forms and consistencies or textures of the horns of ruminant animals form part at least of the characters by which the groups and genera are distinguished from each other; and when in the same latitude or climate, and in a state of nature, they are tolerably constant characters; but in different climates, and especially in a state of domestication, they are much less to be depended upon.

Some have the horns deciduous, or shed every year, as is the case in all the deer family; and in this family, with the exception of the reindeer, horns occur in the males only. These horns grow and are shed every year, increasing in their dimensions and the number of antlers, snags, or branches into which they are divided, as the animal gets older. In their young and growing state, they are covered with skin, and with fur or hair; and when they attain their full growth, and the hair and skin begin to peel off, the season of sexual ardour commences, during which the males are very bold and daring. Soon after this the horns separate from the roots at the "burr," and fall off, and from the time that they do so, till the new ones are again full grown, the animals are timid and peaceable in their dispositions.

The economy of these horns is a very curious matter in the physiology of the animals to which they belong. The development of them is always the greater the more northerly the place which the animal inhabits, and consequently the greater the seasonal vicissitudes to which it is exposed. They use these horns for the purposes of defence, and very formidable weapons they are in many of the species. But they are fit for defence only during a part of the year; and thus we cannot suppose that defence is the chief purpose which they answer. It should seem that a degree of action in the system, beyond what the animals require to exert in the procuring of their food, is necessary at those times of the year when they are not under the influence of sexual excitement, in order that it may be turned to this purpose at that season when it is required; and the production of this vast quantity of horn or rather of hone, for it resembles bone more than it does the substance of true horns, or horns which are persistent for the life of the animal, and formed upon cores of bone, by successive layers applied to the inside of the horn every year, is the means by which this excess of action in the animals is kept up. When the males of those species, whose natural habit is to have those deciduous horns in the males only, are mutilated, the shedding and reproduction of the horns cease, and they become persistent, and never increase in their size or in the number of their branches, as they do in the entire animal; which farther proves that the production of the horns is connected with the sexual economy of the animals.

In such as have the horns persistent there are no such violent actions; and in some of the races the circumstances with regard to climate appear to be reversed, for generally speaking, the buffaloes, which are natives of countries comparatively warm, have a much greater production of horny substance on the head, often amounting to almost an entire plate across the forehead; and, on the other hand, the bisons, which inhabit the colder latitudes, have the horns comparatively small. In mutilated animals of this family there is also a greater production of horn than in the entire males; so that the production of the persistent horny covering to the core of bones does not appear to be so intimately connected with the sexual character of the animal, as the growth of those horns which are annually shed.

The most remarkable character, however, of the ruminantia, and the one by which the whole race are distinguished from all other mammalia, is the complicated structure of the stomach. This invariably consists of four distinct portions. The first, usually called the paunch, is of large dimensions, but appears to answer very little purpose except that of a mere receptacle for the food; and as those animals do not chew their food as they swallow it, they collect it much faster than animals of different orders which feed on substances not very different in their nature. Thus, for instance, unless the pasture is exceedingly bare, a cow can collect as much food during one part of the day as shall enable it to lie down to rest during another part; whereas if a horse is placed on the same pasture it will leave it more hungry than when it entered.

In this first stomach very little digestion is carried on; but the food sometimes ferments in it, to the great annoyance of the animal, from the quantity of gas generated during the fermentation. This is especially the case when cattle eat green trefoils when there is dew or wet upon them; and in such cases the gas in the paunch so expands that viscus, as to enlarge the animal very much to external appearance, and also to press heavily upon and thus derange the action of the other viscera. In such cases the paunch may be opened by a knife judiciously applied, and the gas let off into the air without any serious injury; but it is safer to introduce, by the gullet, a flexible tube, with an extremity of ivory or other matter pierced into holes, through which the gas can escape. This circumstance is sufficient to show that it is not by any action of the first stomach or paunch that the food is returned to the mouth of a ruminating animal.

This office is performed by the second stomach, which is popularly termed the hood; and the inside of which is formed into cells by membranous divisions. This stomach has a kind of rolling motion, by means of which the food is formed into a sort of quids, and these are the portions of food which are returned to the mouth to undergo the operation of grinding when the animal chews the cud. There are some cases of accident and disease in which animals of the ox tribe lose this power; and the method of cure is dexterously to snatch the quid from the throat of another animal of the same kind, and introduce it into the mouth of the affected animal, where it has every chance of renewing the process with the requisite degree of vigour. It was owing to ignorance of the use of this part of the stomach that the vulgar error of camels carrying an internal supply of water in this part of their viscera, not only for their own relief in the deserts, but for that of their riders, at first originated. Upon other grounds, such as the impossibility of keeping in the stomach of a warm-blooded animal water at a lower temperature than the ordinary heat of that animal, which in the camel is pretty nearly the same as that of the human body, and therefore would form no very refreshing draught to a traveller, this long-believed tale might have been confuted; and recent travellers, who have had the misfortune to lose their camels not very long after being watered in the desert, have made the experiment without finding any water in this cellular division of the stomach, or, indeed, in any other part.

The drink of the ruminantia does not go to the first stomach, because there it would tend to produce fermentation in the green food, and weaken the animal; and as little does it go to this second stomach, because here it would prevent the formation of the food into quids for the purpose of being returned to the mouth. "Chewing the cud" is merely a different pronunciation of "chewing the quid;" and the quids are brought one by one to the mouth, and undergo a complete grinding, mixed with the saliva of the animal; and in this state they are returned to the third stomach, or that which is called the manifold; and it is in this particular stomach that the water which the animal drinks mixes with its food. The process undergone in this third stomach is a sort of incipient digestion; but it is not till the food arrives at the fourth stomach, that the gastric juice mixes with it and the process of digestion is completed. This fourth stomach, which is the only one which very much resembles the stomach of those animals which have only one, is popularly called the "red," from its colour; and in the young it is called the "rennet," because in the young of the ruminantia the gastric juice is specially adapted for curdling milk, and the rennet is used for that purpose in dairies.

Ruminant animals are found in all parts of the world, with the exception of New Holland and the remote isles of the Pacific Ocean, where there were none when first discovered by Europeans. They are conveniently arranged into the five tribes of camels, deer, giraffes, goats, and sheep, including, under the latter, the different varieties of the ox genus.

The camels have no horns, no small hoofs on the feet, and no muzzle, or naked part on the snout, differing in texture and covering from the rest of the head. The nostrils are cleft and their upper lip divided, each lobe of it capable of motion separately from the other one. They have spongy soles to their feet, which are well adapted for moving on the sand, but soon get beaten in rough and stony places. They have a sort of claws on the toes, canine teeth in both sexes, long necks and limbs, and the lower part of the belly closely drawn up under the flanks. The true camels are found in the old continent only. There are two species—the Bactrian camel, with two bunches on the back; and the Arabian camel, with one only. They are kept in a domestic state for their milk, their flesh, their skins, and their hair; and they are also used in the desert as beasts of burden. They are strong, enduring, and patient, but they are not very swift nor very pleasant to ride. On the American continent the lama and alpaco, with some varieties, supply the place of the camels in the old continent. They are animals of much smaller size than the camels, and without humps on the back. They are found chiefly in the Andes in South America; and the natives had reduced them to servitude as beasts of burden before the country was visited by Europeans.

The deer family are much more numerous and much more widely distributed. One genus, the musk deer, inhabits the mountains of southern and eastern Asia. Some of the species of this genus are very small; others produce the drug called musk; and in some the canine teeth, which occur in the upper jaw of the male only, are very long and projecting from the mouth.

The elk has horns in the male only, with a very bread blade, and is an inhabitant of countries near the Arctic Circle. The reindeer has horns in both sexes, and inhabits within the Arctic Circle, being the most valuable animal to the people of the extreme north of Europe. Of the fallow-deer, the stag, and the roebuck, there are many varieties more widely distributed than the rest; and the roebuck has the remarkable property of not being gregarious, or polygamous, the pairs remaining attached to each other for life. These, with a variety of analogous species form the characteristic deer of most regions of the world, though in tropical countries they usually keep the elevated districts. The males in all the species shed their horns annually, and those horns are always more or less rough and branched, but their forms differ a great deal in different species.

Of giraffe, there is but one known species, a native of the forests of Central Africa; it is remarkable for the length of its fore-legs and neck, which last, however, contains the same number of bones as the very shortest necked of the mammalia; its horns are short tubercles covered with hair; its eyes are so placed that it commands a view in the rear; it feeds principally upon the branches of trees; and from its height it reaches them at a considerable distance from the ground. When full grown it is the tallest of all animals.

The goat family, which is a very numerous one, consists of the antelopes, and the goats properly so called. They have the horns with a bony core almost or altogether solid, and the horny matter very compact. They are animals of great lightness or vigour, but differ much in size and appearance. Africa is the great country for antelopes, though they are also found in Europe, and more plentifully in Asia; in Africa they migrate with the seasons in great droves, and some of them are remarkable for the beauty of their forms and the swiftness of their motions. The true goats are more strongly made than the antelopes; and, generally speaking, their hair is shaggy. They are chiefly mountain animals; and some of them are remarkable for the length of their leaps, and their sure-footedness upon the rocks. They sometimes meet with the antelopes in very lofty situations; as for instance, the chamois which is an antelope, and the ibex which is a goat, are both found on the summits of the Alps. Of this family the antelope is rarely tamed, and not at all formally domesticated; the goat, on the other hand, is a domestic animal in almost every part of the world.

The remaining family of the sheep and oxen inhabit lower down, and are less fleet in their motions than the antelopes, and less hardy and vigorous in proportion to their size than goats. They have been so long domesticated, that it is not easy to say whence the races, which are now so valuable as domestic animals, originally came. There are wild sheep in some elevated places of southern Europe, which are called moufflons; but whether they are the parent race of any of the domestic sheep is not known. The ox tribe are more in a state of nature in some parts of the world; and those which are found in the north appear to be more bold than the southern ones. In Europe there are still a few which are called bisons or wild bulls; and in North America, there are very large and powerful animals of this family still in a state of nature, though their numbers are much reduced in comparison with what they were when that part of the world was first discovered.

From the use to which all the parts of their bodies can be turned by man, from the tendency which many of them have to come near his habitations, and the readiness with which they give up their freedom in wild nature, in order to enter his service, the ruminating animals are objects of great interest; and it is difficult to mention them, and resist the enticement of going into some of the particulars; but this would be altogether incompatible with our limits.

CETACEA.

We have already mentioned almost all that we can afford to say respecting the mammalia of the sea, or of the waters generally. There is a common character which runs through the whole of them—namely, that of warm-blooded animals, breathing the air, but yet adapted by their structure to reside chiefly in the water.

The herbivorous ones are found only in the fresh waters of tropical countries. One species, the lamantin is so plentiful in some of the great rivers of America, that its flesh is sold as butcher's meat; there is another one nearly allied to this in the rivers of Central Africa; and there is a third, somewhat different, among the islands to the eastward of India.

The whales, properly so called, are distinguished as toothless whales, whales with teeth in one jaw only, and whales with teeth in both jaws; the last are smaller in their size than the others, and are distinguished as dolphins, porpoises, and other names. One remarkable genus, the narwhal, has one of the tusks in the upper jaw produced in a spiral form, and of an ivory colour and texture; and this tusk projects beyond the jaw to about half the length of the body, the whole length of which is sometimes not less than twenty-four feet.

MARSUPIALIA.

The leading character of these extraordinary mammalia is the double gestation of the females, the earlier part internal in a uterus, and the subsequent part attached to the mammæ, whether these are or are not, in whole or in part, included in a pouch or marsupiam in the belly. Information respecting some parts of the economy of these very singular animals is still wanted; for in different species there are different degrees of development of the marsupiam or pouch, some having it a complete receptacle and protection for the young, persistent or remaining at all times, though in a state of greater excitement or action when the young are in it; while in others it does not appear to be at any time so much developed as to conceal the mammæ.

The point upon which information is especially wanted, is what relation the structure of the uterine and marsupial parts of the gestation have to each other, according as the pouch is more or less developed. The analogy would lead us to the conclusion that the marsupial part of the gestation is longer as compared with the whole in proportion as the pouch is more fully developed; but the case is so curious a one that we cannot trust to analogies; and it is not very easy to arrive at the truth by direct observation. One point has, no doubt, been ascertained at the London Zoological Gardens, with regard to the great or common kangaroo, which is one of the most perfectly marsupial of the whole, namely, the duration of the internal gestation; and when the young have once made their appearance in the pouch, the length of time that they require to come to maturity is a matter of easy observation. It has further been supposed, though not actually observed in the case of the kangaroo, that the mother makes use of her lips in transferring the young from the entrance of the vagina to the pouch, and there is little doubt that many if not all the order do the same.

It is yet further remarkable that, in these animale which use the teats more for the bringing forward of their young than the common mammalia, should yet have those organs of a more transitory nature. The females of all mammalia have a certain additional degree of excitement and developing of the mammæ against the time that they are required by the young; but it appears that, in some of the marsupialia, there is an almost total absorption of those organs at the time when they are not wanted, and a development of them, amounting almost to a reproduction, when they are wanted. In the most singular division of the order which are small animals inhabiting the earth and the muddy pools of Australia, and which, from having but one passage for all discharges from the body, as is the case in birds, are called "monotremata," the mammæ never assume that conglomerate form which they do in the common mammalia; but the milk oozes through pores in the skin. These circumstances have led some of those naturalists who are carried away by loose analogies, to suppose that such animals lay eggs like birds; and some of the more ignorant, and on that account more confident compilers, have given figures of the eggs in their books. But these animals are true mammalia, though singular ones; and their young are brought forward internally, until they can perform the more important vital functions: and they feed for some time on their mother's milk.

These characters are common to all the mammalia, however much they may differ in other respects, and they are always attendant upon a peculiar structure of the more important systematic organs, so that they never can be mistaken by one who observes with anything like even a moderate degree of attention.

We know not the period of uterine gestation in all the species of these curious animals; but we have no reason to suppose that it is the same; and the probability is, that the young come early into the marsupium, according as that is more perfectly developed. Among the common mammalia, which have no marsupia, there are great differences in the development of the young at the time of their birth. Some are perfectly formed, and able to walk almost the instant they are dropped; others are blind, naked, and incapable of motion for some time; and, though the subject is one of considerable obscurity, it seems to be the law of nature, that the more perfect the animals are after they come to maturity, they require the more nursing from their mothers in the early stage of their existence. This holds in the case of birds as well of mammalia; for we find that the feeble flyers and birds of limited resources can run about the moment that they leave the shell, while those of powerful wing are naked and callow. In all this, and it might be traced through every department of being, there is a most important lesson to us. That which is to be superior and important demands, even in the working of nature, additional labour and attention; therefore, if we would excel in anywise, we must be both skilful and diligent.

Some of the marsupial animals resemble one order of the common mammalia and some another, only there are among them no types of the more characteristic beasts of prey, or of the pachydermata or the ruminantia.

It would be inconsistent with our limits to institute a minute inquiry into the differences between the marsupialia and the common mammalia; but, as we already hinted, there is a particular look of stupidity, or coldness of character, about all marsupial animals, which is not found in the true mammalia. No marsupial animal is very violent or vicious; and some of them are among the most gentle of all animals: but their gentleness appears to be passive, and kind treatment does not call forth those expressions of gratitude which it so obviously does in the more intelligent of the common mammalia. It does not appear, either, that there is any attachment of these animals to each other; for, though they continue the race, and the mother pays some attention to the young, as is the case with all animals which require the mother's care, even these affections seem to proceed from a low degree of animal instinct; for even the female kangaroo, which is naturally a vegetable feeder, eats her own young if they happen to die in the pouch. In the skeleton, the marsupial bones attached to the exterior edge of the pubis, are the principal characteristics. The mammæ of the females are always situated on the belly, or in the groin; and the internal uterus is doubled in almost all the species. In respect of their feeding, no general rule can be laid down; neither is it easy to say what is the general character of country best suited for the whole. In this respect, however, and it is an important one, inasmuch as they are all very local animals, they may be said to occupy three distinct kinds of countries, which, however, are all peculiar in their kinds. In the first place, the hassocky plains, which consists of large tufts of coarse grass with barren spaces between, and from which the vegetation, scanty as it is all times, is apt to vanish entirely in the dry seasons, are inhabited by the kangaroos, which are remarkable for the great development of the hinder parts of their bodies as compared with their fore parts, and which can move from tuft to tuft with vast bounds or leaps. They are of different sizes, from the great kangaroo, which is about as large as the smallest species of deer, to others not larger than a common rat, which last inhabit thickets and holes in the ground. These animals most nearly resemble the rodentia in the structure of their mouths. They have four cutting teeth in the upper jaw, and two in the under, with five grinders on each side of both, but no canine teeth in either jaw. Their head is lengthened, their eyes and ears large, the latter sharp pointed. The fore legs are exceedingly short, so as to be of little use in locomotion. The hind legs are remarkably long; and though the animal rests on the whole length of the tarsi, on these, when standing on all fours, in its feeding attitude, it has a very singular appearance. There are five toes on the fore legs, and four on the hind; but the inner two of the latter are united, so that they seem but one. All the toes are furnished with large and strong claws; and those of the middle toes of the hind feet are truly formidable weapons, a kick with which inflicts a very serious wound. These animals are found only in Australia, of which they are the natural field mammalia. There are a good many species and varieties, but they agree in their common characters; and they all have the marsupium so much developed as to be capable of receiving the young and carrying them from place to place during the very rapid motions of the animals.

Secondly, there are some other Australian animals which come more nearly to the character of such of the rodentia as dig in the ground. These are very slow animals, remarkably quiet and inoffensive, having only cutting teeth and grinders; with five toes to each of the feet, and those toes divided almost to their bases; and in this, and in the claws with which they are furnished, bearing a slight resemblance to the feet of birds. The principal animals of this division are about the size of the common badger, and very low on the legs; they are the kaola and the wombat. Both of them are easily tamed, and their flesh, as well as that of the kangaroos, is not unwholesome, though very inferior to that of the mammalia which these animals most nearly resemble.

A third Australian race are more carnivorous in their character, though their structure and general habits would lead us to conclude that they feed more on carrion and dead matters than on living animals. They are styled dasyuri, from the fact of their tails being covered with long hairs. Some of them are as large as a wolf, and commit depredations in the flocks of the colonists, while others are small, about the size of cats. They have all the three kinds of teeth, with the canines large and the first cheek tooth trenchant, or of a carnivorous character; but the remaining ones, of which there are five in each side of every jaw, are insectivorous. These animals are not numerous in any part of Australia; and the large ones are found only in Van Diemen's Land, being quite unknown in New Holland. Some of them bear a slight resemblance to the dog, but they entirely want the intelligent expression of that animal; their tails are like the tails of rats; and there is something indicative of ruggedness and want of strength in the aspect of the mouth.

There is a fourth race in the same countries, which seem to combine the characters of both the two last mentioned. They have all the three kinds of teeth in greater number than most other animals, but subject to variation. Their muzzles are very much elongated, and some of them have the nose projecting far beyond the points of the jaws. They live in holes of the earth and hollow trees, feeding chiefly upon insects and small reptiles, which abound much in Australia; and from their appearance and habits the colonists call them badgers, to which however they have no resemblance excepting perhaps a little in their modes of life.

None of the races now mentioned have the tail prehensile, or capable of laying hold; but there is a fifth race found partly in New Holland, and partly in the eastern islands, which have the tail prehensible, and some of the species have the skin of the sides capable of extension so as to act as a parachute in breaking their fall. They all are animals varying considerably in the characters of their teeth, their sizes, and their modes of life; but in general they may be considered as miscellaneous feeders, consuming equally the fruits and leaves of trees, and the insects by which those trees are inhabited. They live chiefly or exclusively in the woods, and nestle in hollow trees, from which the woodsmen drive them by smoke, and find that some of them at least are tolerable eating. Australia is more a country of hollow trees than any other on the face of the globe; for there are comparatively few species of trees there which do not become rotten at the heart long before they show any signs of external decay. This gives great employment to those insects which feed upon decaying wood, and the insects again furnish a copious supply of food for the animals of which we are speaking. Those marsupialia of which we have given an outline, are all eastern animals; and though several of the division last alluded to are found in New Guinea, and some of the other islands immediately to the north of New Holland, yet that country is the proper locality of those animals, and they are its characteristic mammalia. The country is as peculiar as its inhabitants are; but it would require more space than we could afford, and more information than has yet been obtained, so far to investigate the connexion between Australia and those animals, as to be able to say why, of all the large extent of lands upon the surface of the earth, Australia alone should have its characteristic mammalia marsupial. The question is, however, one of great importance in establishing the general law of connection between animals and their countries, which law is not only of great use in guiding us to the knowledge of nature, but it is one by which we are enabled very forcibly to see how, by the kind providence of the Creator, all the parts of creation work together for the common good of the whole.

The only other country in which there are marsupial animals is America; and they are chiefly wood or shore animals there, and confined to the warm and temperate parts. Even in these they are not the characteristic mammalia; for different species of the cat and dog families are the carnivorous animals there: deer and oxen are the vegetable feeders of North America; tapirs and peccaries are the characteristic vegetable feeders, at least on the ground, in the tropical forests; and the rodent animals and armadillos are characteristic in the more dry and extended plains. Thus we may say that the marsupial animals are not at home in America as they are in the eastern world, but that they live as strangers in a land which is even by nature in the possession of other races.

Some of those American animals have the marsupium developed, and others have not; they all however go by the general name oppossums, and they have all a considerable resemblance to each other. They have the three kinds of teeth; and in their general appearance they most resemble the insect feeders of the common mammalia; but then, in the division of the toes and many other particulars, they resemble the marsupialia of the east. On the ground they are plantigrade; but most of the animals are climbers, and some have the thumb on the hind foot acting against the other toes like a rude hand. The largest are about the size of rabbits. They eat insects and small animals; and some of them frequent the sea coasts and feed upon crustacea and mollusca.

Such is a very brief outline of the mammalia according to their kinds, and in their native countries, and we shall now take a still more hasty glance at the birds, which form the second class of vertebrated animals; and, though one class differs from another in its element, its action, and the purpose for which it exists, they all equally proclaim the merciful goodness and infinite wisdom of that Being who has so wonderfully framed and furnished the world for our contemplation and our use.

CHAPTER V.

BIRDS.

Bird, in all languages, has one meaning—that which flies, mounts aloft and dashes along; and this agreement of mankind in the general name of these animals shows how well their leading character is understood by all nations, and how forcibly it strikes even those whose range of contemplation is most limited. So remarkably is this the case, and so much does it show the greater familiarity which men in the rudest state have with birds above all animals, that when our navigators carried sheep to stock some of those remote islands with which the wide expanse of the Pacific Ocean is spotted over, the simple people, unable to give them any specific name, declared at once that they "knew they were birds."

The fact is, that of all the living creatures which God has formed, the birds are the most open to observation and the most familiar to human knowledge. Mammalia in a state of nature dwell comparatively in secret; and in a thickly peopled country, such as England, one may traverse the fields for days and weeks without the certainty that a single specimen of mammalia in a state of wild nature shall be seen, unless the observer has previously informed himself as to where and at what hour he is to look for them. The birds, on the other hand, are, in one or other of their species, continually before our eyes. Man cannot build a city so close, so large, so thickly peopled, so bustling and full of art and activity of all kinds, as to exclude the house sparrow; and if his habitation is buried in the depth of the closest forest, the house martin will find out his windows as resting places in the summer; and when winter lays the beauty of the year in ruins, the redbreast will come to his threshold, or the sill of his window looking out for its supply of crumbs; and whenever a more genial ray of the sun gives promise that a new year is to call the world without into growth, and life, and activity, it will perch on the naked wall or the leafless tree, and cheer him with the melody of its little song.

There is something at once very delightful and very instructive in this familiarity of the birds with the human race. Among animals, birds are the models of mechanical science. There are no motions, and no media of general motion, for which birds are not adapted. They ascend, they descend, they dart along in straight lines, they wheel in circles, they float as motionless things on the thin air, they run along the ground with speed in some of the species equal to that of the swiftest mammalia, they ride on the surface of the waters as lightly as though they were bubbles on the waves, but bubbles not to be broken; and some of them dash through the volume of the river, the lake, or the sea, even in the violence of its tempest's swell, so as to catch the fishes, the proper inhabitants of the water, by outdoing them in speed.

Now all those varied motions, and in their smaller distinctions they are countless, and some of them are capable of being continued on the stretch, till the bird has passed over hundreds and even thousands of miles, are performed by means of material organs, acted upon by the common animal powers of sensation and volition; and those organs are in all cases the very best adapted that fancy could suppose to the object which the bird has to accomplish. Nor is it in the single organ only that we find this matchless display of Divine wisdom. If any one particular kind of action is that upon which a bird mainly depends, or which constitutes what may be called its natural use in creation, we find the whole structure of the bird consenting to, or in accordance with, that particular kind of action, in a manner which is altogether wonderful. If it is to cleave the air with vast rapidity, as is the case with the eagle and the falcon, we find the form of its body exactly that which our utmost science would recommend for such a purpose; and also the power of action in the bird concentrated upon the wings. But if, in addition to this merely rushing through the air, the bird has some other severe labour to perform, as, for instance to strike down its prey on the wing, to pounce upon it on the ground, or to snatch it from the waters, we find that the bill or the feet, or whatever may be the weapon most peculiarly adapted for this purpose, divides the active strength along with the wings, in proportion to the necessity which there may be for them.

If the prey is of smaller size, and on that account more difficult to capture on the aerial flight, we still find the structure of the bird brought up exactly to that form and character which is the very best suited for its purpose. Take, for instance, the common swift, or largest of our swallow tribe, which seeks its prey in those regions of the air which are elevated above the tops of ordinary houses, then we find that the whole strength is given to the wing, and the wings and forks of the tail are drawn out to sharp and stiff points, so that the bird can turn upon any of them as centres, as it follows the mazy wheelings of its insect food. Nor is it unworthy of remark, that birds which like this food, or fly high in the air, generally make their nests in lofty places.

If, on the other hand, the bird is to feed and inhabit chiefly upon the surface of the ground, where that ground is thick with vegetation, which, though it conceals the bird, can also conceal its enemies, we find the organisation of the bird quite different. In this case the wings are short, broad, and hollow; and the tail which is the principal instrument in ascending and descending, is capable of being spread out like a fan, and sometimes contains supplemental feathers, which act as a parachute, and let the bird gently down when it wishes to alight. What we have now mentioned is the case with all the poultry birds, wild and tame, and whether they inhabit the lowland field or the upland heath; and the produced feathers which act the part of a parachute are very conspicuous in several of the species which perch upon trees; and also in the birds of paradise and various other races which, in the warm regions of the world, hunt over the tops of the forests, and are often so gay in their colouring that they are seen streaming through the air like meteors.

If the habit of the bird is to be on the earth only, and to reside in the open wastes where no lurking foe can be concealed, from which to escape it would require to take to the wing, then the wing of the bird is comparatively or altogether useless for flight, and the strength of its apparatus of motion is concentrated upon the legs. This is the case with the whole of the ostrich family, which inhabit the extensive and thirsty deserts; and there is no approach to it in other birds in proportion as their mode of life corresponds. But though the wings of such a bird as an ostrich are incapable of raising it into the air and supporting it there in continual flight, it must not be supposed that they are on that account useless parts of the structure; on the contrary they steady the course of the bird as it runs along, which is necessary in an animal that has the axis of the body nearly parallel to the horizon, and is supported from a single part of the cross section, namely, the articulation of the legs. For the wing, however small it may be, strikes outward against the air, and thereby contributes much to the progressive motion of this bird; accordingly we find, in all the ostrich family, that though the wings are destitute of quills or flying feathers, properly so called, they are still tolerably well supplied with muscles, and remarkably active as flappers, or in rowing against the air like oars or paddles. The apteryx of New Zealand is the only bird which has the bones of the wing so completely fastened to or contained within the skin of the side as to be incapable of motion; and the short legs, long toes, and scraping claws, similar to those of a fowl, with which this bird is furnished, show that it is a walker and not a runner, and as it has no fleet motion it can dispense with the use of the rudimental wings both for balancing and rowing along.

We have a remarkable instance of the partial use of wings in aiding the fleet career of birds on their feet, in some of the species of running birds, which frequent the shores of the sea, and other margins of waters at certain seasons of the year, but also require the use of comparatively powerful wings to support them to places at other seasons. Of these birds the sandpipers (*tringa*) are perhaps the most remarkable. They run along the sands whistling, and wailing, and screaming, in very plaintive but not unpleasant notes; and they run with so much velocity, as to distance the speed of a common dog without even troubling themselves to rise on the wing. Now these birds have wings of very peculiar form. The bones of every bird's wing consists of three parts, which bear some resemblance to the arm, the fore-arm, and the hand, only the bones of the wrist are few, the thumb which carries what is called the bastard wing is very little developed ; and the finger bones are long, and generally united together for the whole or the greater part of their length, and have the joints of their phalanges only marks and not moving articulations. To the part which answers to the hand, the primary or principal quills of the wings, or those which are most efficient in powerful flight, are inserted. Immediately inside these, and upon what answers to the fore-arm in man, there are inserted the secondary quills, which are smaller and shorter than the primaries ; and about and above the elbow joint there is a third series, which are called the tertiary quills in the wing. Now those tertiary quills require for their motion the action of the shoulder joint only, while the secondaries require the action of two joints, and the primaries the action of at least three. It will readily be seen that the more joints that are called into action, the more must the general system of the animal be fatigued; because the action of every additional joint requires that of additional muscles: consequently if a bird can perform any motion with the first or shoulder joint of the wing only, that motion must be much less fatiguing to it than if the whole wing came into play.

Now, in the running birds, to which we last alluded, the tertiary feathers are so much produced, in comparison with those of the secondaries by which they are immediately succeeded, that the wing appears as if it were two wings, or at all events a wing in two parts, one of which is smaller and nearer the body, and the other larger and more distant from it. The wing next the body is moved entirely by the shoulder joint, while the more distant part plays easily and without fatigue upwards and downwards in the air. Thus, while the bird runs it makes use of the proximal part of the wing, to assist in its running, as the short wing of the ostrich does; and if it is at last obliged to take flight, the more distal portion of the wing is fresh and vigorous for that purpose. This union of wings which are simple helps to the feet, with wings capable of regular flight, is perhaps most perfect in those birds to which we have alluded; it is not, however, peculiar to them, for all birds which run with "the alternate foot," that is, which do not hop or lift both feet in their march on the ground, keep the wings partially extended, and move them in proportion to the rate of their progress. Hopping birds also raise the wings whenever the hop is so extensive as to be an exertion to them; but in them the extended wing seems to act more like a parachute than anything else.

Birds, from the general command which they have of the surface of the earth whether that surface be covered with land or water, have a far more extensive range of pasture than the mammalia. They have also powers of ascending and descending by making use of the air as a ladder, in like manner as they make it a path-way in their locomotion; and thus they have hill and dale, mountain and valley, much more at their command than the mammalia can possibly have. Owing to this, they do not require the same resources in animal sagacity; and the consequence is, that the nervous system is not so well developed, or the senses and perceptions so perfect in birds as in mammalia.

Their power of ranging over the broad waters also fits a number of them for obtaining their food there; and as the water is far from being the least productive portion of the earth's surface, we might perhaps expect that many birds should be so constructed as to be capable of finding their food from it. This is at all events the case; and we find them skimming over the surface of the waters on long and easy wing, riding buoyant on that surface, and rowing themselves along with feet which have the toes united by membranes, and are so articulated and formed that they are paddles of the most effective description. We also find others which can with facility plunge below the surface, and dash along there by the joint action of their wings and feet; and from this to the opposite extreme, of being able to fly over the water, but not swim on it or dive in it, we have all the intermediate gradations. And we may be prepared farther to expect that there will be a general correspondence of the food and habit of the bird more toward the one of these extremes in some cases, and towards the opposite extreme in others. This we find to be the fact; for the cormorants and birds of that character which do not generally inhabit the waters, though they find their prey there, have the webs of their feet so formed that they answer better for enabling the birds to ascend up from the water, than for giving them progressive motion in it. These birds have the hind toe of considerable length, and included in the web with the others, but the whole web turned obliquely inwards, so that though the foot does answer for swimming, it is by no means a swimming foot of the first class.

As opposed to this we have, in those birds which swim and dive most habitually in the clear waters, the hind toe merely rudimental, and the web confined to those front toes which can act as one paddle. Along with this we have the legs so articulated that this paddle, when it impels the bird forward, acts on the water with the maximum of effect, but turns on edge when it is recovered, and thus is brought to the position of least resistance from the water, while preparing for new action. In such cases, too, the foot is articulated far in the rear of the bird; and even in this, simple as it may seem, there is a beautiful display of design. The water on the fore part, and against the sides of the bird, until these sides begin to narrow towards the tail, offers to the bird a resistance proportional to its motion; and the bird has, backward to this point of its length, to divide and stem the resisting water. The moment, however, that we get behind this point, the relative state of the bird and the water is altered; for while the fore part of the bird drives the water, the water follows the hind part of the bird, and thus those feet which are so articulated as to work far backwards, act against the water, where its natural motion assists, rather than retards them: and when we consider this, and that it is a necessary result of the common property of water, by which it obeys the laws of gravitation by endeavouring to preserve its equilibrium or level, and of the structure of the bird regarded merely in a mechanical point of view, it is impossible for us to avoid perceiving that we are to seek the foundations of our best and soundest mechanical knowledge in those adaptations of creature to element which the Almighty has made. It would be easy to go through the whole structures and the whole habits of the feathered tribes, and from the contemplation of these jointly to show that we may search in vain for any such school of mechanics as they present to us without labour and without expense; but interesting as this subject is, our limits forbid us from entering farther upon it.

It would be superfluous to describe the general form of a bird, or to say much of the parts and their coverings, because these are matters of common observation. The mouth of a bird is always a bill, or two mandibles of horny substance, placed the one above the other, and having the principal motion in the lower mandible, as is the case in the mammalia. The nostrils of birds are placed at the base of the bill or in its substance, and they are variously protected by membranes or feathers, according to the habits of the species. The eyes are placed laterally, and they have their principal direction varied according as the bird has more use for them in one direction or in another. In birds which fly high and seek their prey under them, the eyes are so placed as to command the view downwards. In birds which fly straight forward in the twilight, the eyes are directed more forwards, and they are larger, and generally surrounded by radiated feathers which appear to have some influence in concentrating the feeble light upon them. The ears of birds are never developed externally, but they are covered with peculiar feathers; and in some birds, at least, the sense of hearing is very acute. The feet of most birds consist of four toes, three to the front and one to the rear; but sometimes all the four are turned to the front, as in the swifts; sometimes two are turned to the front, and two to the rear; sometimes the external front one can act either forwards or backwards; and in different birds the toes are more or less connected with each other by membranes. Almost all birds are digitigrade, or walk on the toes only, and the naked part, which we are in the habit of calling the leg, is the tarsus or foot bone of the bird. In most species this tarsus is naked and covered with scales, and in many of the wading birds, a portion of the tibia or true leg above the tarsal joint, is bare of feathers, which portion is called the garter. The covering of the tarsi of birds is one indication of their habits; land birds having these parts covered with imbricated scales, which lie over each other, and have their edges free; while wading birds and water birds have the scales reticulated or inclosed in a membranous net-work at all their margins. In some birds the tarsi are feathered, and even the toes partially: and this provision is found only on birds which inhabit very cold places, or have powerful action of their feet. The feet of birds never contain much muscle, but consist of bones, cartilages, and ligaments, covered by the skin and its appendages, the muscles being situated on the upper parts of the leg. In general the ligaments suffice, without any muscular action, to close the toes, by the mere bending of the upper joints of the leg; and by this means birds are enabled to cling to their perches without any exertion, and consequently without any waste of their systems. The feathers of birds, which are the general coverings of their bodies, and which are not possessed by any other class of animals, are of three kinds—clothing feathers, feathers for flight, and supplemental feathers, of which the use in all cases is not very well known. The clothing feathers usually form a very close investment, are generally imbricated one over two, and their curvatures are beautifully adapted to those parts which they cover; those feathers are sometimes intermixed at their roots with a separate covering, which gets the name of down, and which forms the radical portion of the webs of most clothing feathers, and which sometimes issues as a supplemental branch from the inside of the feather, just above the barrel or hollow part.

The feathers of flight are the larger ones of the wings and tail; but both of these are, according to the habit and action of the bird, fortified toward their bases by rows or layers of shorter feathers, which add greatly to the strength and stiffness of the flying parts, without adding much to their weight. These are called upper or under coverts, according as they are applied to the upper or under sides of the flying instruments.

The supplemental feathers are found on various parts of the body; and it is not very easy to see what is their use in all cases, though we cannot doubt that in every case they have a use. Sometimes they appear as a round tuft or crest on the head, the precise purpose of which we are not very able to make out. At other times they are in the form of floating crests from the hind part of the head; and in these cases we can generally understand that they guide the direction of the head when darted out in rapid motion, just as the feathers of a dart or arrow guide the direction of that weapon. When they are in the tail we may presume that they have the same influence on the general direction of the body of the bird; and when they are loose and flocculent, and issue from the shoulders or back, we naturally suppose that they assist the bird in floating gently through the air with little muscular exertion.

The points of wings and tails are tolerably good characters in birds. The power of ascending and descending is in proportion to the general development of the tail. Birds which have chiefly straight forward flight in the free air, have the tail nearly squared over at the extremity; those which wheel about in the free air, often have it forked; and those which make their way among the branches of trees, have it rounded or wedge-shaped. These forms are however so much mixed up with other characters in the different races of birds, that we cannot come to any very positive conclusions by merely regarding them singly.

The voices, as well as the appearances of birds, are much more pleasing to us than those of the mammalia, or indeed of any other class of animals. The voice of birds depends but little on the form of the mouth; because its proper organ is at the lower end of the windpipe and not at the upper; and hence in them it is the windpipe, and not the mouth which modulates the voice. From this arises the pleasing variety of their notes, which make the groves and coppices so sweetly melodious when the vernal season collects the winged tribes to such places, and stimulates them to perform the grand labours of the year. On the contrary, the natural voices of the mammalia are, generally speaking, unpleasant; and if we are pleased with the bleating of sheep, the lowing of oxen, or the barking of dogs, the pleasure is a secondary one, arising from the service which these animals render to man. On the other hand, the song of the birds, in wild nature, and without the aid of any association, are often highly delightful; and the spring and early summer would be deprived of many of their charms if the birds were to become silent. Nay. even when the missel thrush sometimes raises his song amid the desolation of the year, that song tells us that spring is coming, and thus bears some resemblance to the bow of hope amid the blackness of the tempest.

From their power of careering over long distances, birds are the most seasonable inhabitants of the earth. They can travel from the regions of the equator to the margins of the polar ice, in less time than a man could walk the breadth of England; and this celerity of motion enables them to perform labours in the economy of nature, which could not be performed by any other creatures. In Britain we do not see the full working of this seasonal migration; but still we see enough of it for convincing us that it is a most important part of nature's economy. As the sun divides its genial influence on the two hemispheres in the course of the year, giving each the alternate succession of summer and winter, there is a seasonal alternation of all sorts of living creatures, and all sorts of vegetables upon which a bird can feed. There is not only this, but in proportion as the latitude is nearer the pole, there is a longer feeding time every day for the bird which migrates northward; and, therefore, as the rearing of their broods is no simple labour with the feathered race, those northerly climes answer well for this purpose. It so happens too, that as the northern regions of the world get more productive of food, and the day gets longer for collecting it, the regions of the south become burnt up so as not to furnish a supply. On the other hand, when winter returns to the regions of the north, and the snow falls and the water congeals, so that there is food only for a very limited number of creatures, and these of only very peculiar structure and character, the season has again set in, in the southern climates; and thither the birds return, and enjoy the bounty of Him who provides for the want of every creature in its season.

This migration is not confined to the little warblers which are so joyous in our groves, and which, while they delight our ears with their songs, tend so much to preserve our gardens and copses, and even our field crops from the ravages of devouring insects; for it extends to an endless number of races. As the waters in the warm climates ebb away, and the animals and animal remains which they leave behind begin to be exhausted, numerous flights of cranes, storks, and other birds with long legs and adapted for wading, find their way to more northerly countries; and, as it is beautifully expressed in the sacred volume, "know the times of their coming," with a certainty which would be wonderful if it were not part of the system ordained and directed by the Almighty. Those seasonal movements of the birds not only furnish us with a constant succession of objects of knowledge and delight, and furnish us with the keys of nature in parts of the world which we cannot possibly visit, but they also admonish us of the lapse of time, and warn us to perform our labours and discharge our duties while it is yet day, because "the night cometh in which no man can work."

As birds are the most aerial of all creatures in their external structure and their motions, they are also the most aerial in their internal structure and their breathing. Taken in general, the action of their system is more vigorous and their temperature higher than that of the mammalia; and as the breathing of an animal is ever in proportion to the activity and heat of the system, and the birds, exposed as they often are to the full action of the wind high above the surface of the earth, have not the same calmness in which to breathe, as the mammalia have in their shelter upon the ground, we might naturally look for some additional apparatus in the way of breathing. For such we do not look in vain; for the interior of birds is not only filled with air cells and air sacks, but their very bones are hollowed out so as to admit a free passage to the air; so that by this means, the renovation of their blood by the action of the air is not confined to the lungs as it is in the mammalia, but air has access to every important blood-vessel, and the bird is capable of breathing all over. Not only this, but there are some birds which have the means of making the air of use to them in the breaking of their fall and the altering of the specific gravity of their whole bodies, and of that of the several parts. The gannets and cormorants, and some other birds which have the habit of descending from a height and catching fishes in the sea, have the skin of the breast attached to the flesh only by ties at certain places; and as those ties are elastic, they admit a portion of air to be taken in. Such birds plunge head foremost into the water in the act of capturing their prey; and there is no doubt that the elasticity of this air takes off the shock that would otherwise be produced by the rapid contact of the water; and not only this, but it also helps to give buoyancy to the fore part of the body of the bird, and enables that to rise with greater ease when the bird, having accomplished its purpose in the water, again prepares to take the wing and mount upwards into the sky.

In the production of birds there is a wonderful uniformity; and we find among them no such difference as there is between the ordinary and the marsupial mammalia. Every bird, whatever may be its nature, its form, or its size, is produced from an egg; and there is more similarity in their general characters among the eggs of birds, than there is among the young of any other class of animals when they leave the body of the mother. Every bird's egg is covered with a hard and brittle shell of salts of lime, lined with membrane, and containing a yolk and a white, at one particular point of the union of which there is contained the embryo or original germ of the future bird. The egg has this curious property too, that in whatever way it is turned or rolled about, the germ always remains toward the upper side; and it is essential to the quickening of many eggs, at least during incubation, that they should be moved to prevent the yolk from descending through the white; because if it should do so and the atmosphere act directly upon the yolk through the shell, and without the intervention of the white, the egg would become putrid or addled and not produce a bird.

The membranes which invest the yolk of an egg, and with which the embryo or rudiment of the bird is connected, are exceedingly curious; and, strange as it may seem, there is in the egg, though as yet it has no active life in itself, a rudimental portion of two lives,—namely, a certain part of the life of the mother bird, which is to accomplish its purpose during the incubation, and then to be no more; and the rudiment of a young life for the offspring, which, if it meets with no calamity, shall come to maturity, continue its race, and live for its appointed time. It happens in the case of those membranes within the egg, as it does in that of the placenta of the mammalia, while the young remains in the uterus, that there are distinct vessels belonging to the maternal part and to the offspring; and then we can follow those vessels downward from the larger maternal ones until the most powerful microscope loses them at the surface of contact, and that we can find those belonging to the offspring a little on the other side of this surface, and trace them onward to the vital parts of the said offspring; but when we have done this our observation is at an end; and there is something in that mysterious contact of the two lives, which contact is at once a union and a separation, which mocks at our philosophy and sets at nought even our fancies and conjectures,—so wonderfully are the springs of life veiled from mortal eyes.

The great difference in this respect between mammalia and birds appears to consist in the internal heat of the mother being necessary for the young of the mammalia, until it is so far developed that the principal actions of the vital system have begun; while in the birds, the egg is in such a state that the requisite degree of dry heat continued for the proper length of time will bring the young to maturity independently of the mother. The young of the marsupial mammalia, when they are transferred from the internal uterus to the pouch, have some slight resemblance to eggs; but still they have advanced much farther than in the case with the eggs of birds; and while the vitality of a bird's egg can be preserved for a considerable time, it is doubtful whether the embryo of a marsupial animal could exist for five minutes, or even for one minute, unless applied to the teat.

But though the heat of the mother is not absolutely necessary for hatching the eggs of a bird, this is the heat generally applied, unless in those cases where the two parents perform the incubation in turn. It has often been said that the ostrich leaves her eggs to the chance heat of the desert; and it is true that not the ostrich only but very many birds which lay their eggs upon the dry sand, leave them and go forth to feed, while the sun is warm and the air dry; but as there is generally dew upon such places during the night, from the sand cooling much faster than the air over it; and as this dew would injure the eggs, such birds return to them and protect them before the dew begins to form; and if it should rain during the day, they sit most patiently, and for the sake of their offspring abide the pelting of the falling drops; and not only so, but place their bodies in that position by which the eggs shall be best protected from any chance of injury.

The labours of birds in the construction of their nests, the differences of those structures, and the degree of ingenuity and apparent science with which many of them are constructed, form a most interesting part of the rural history of the year; but it is a part upon which our limits forbid us from entering; and therefore we must be contented with a few remarks on the different orders of birds, and the characters which distinguish those orders from each other.

Order I. *Accipitres*, or birds of prey.— These are the most powerful birds of the whole class; and their habits agree with their structure, inasmuch as they all in a state of nature live upon animal food, and the greater number of them kill the prey which they eat. They occupy the same place among birds which the carnivorous division of the order carnaria does among mammalia.

Their characters are, the bill and claws crooked and very strong, though varying in form and in strength with the characters of the animals: and by means of these they prey upon other birds, or reptiles, and on the smaller mammalia. The upper parts of their legs are very muscular, which indicates a great power of action in the toes and claws; the tarsal bones are seldom very long in proportion to their strength; and the under parts of the toes are furnished with elastic pads, by means of which they maintain their hold on their perches without blunting the points of their claws. In the more sanguinary ones the claws are the principal instruments of death, for which purpose their under sides are furnished with two trenchant or tearing ridges separated by a groove; while those which are merely instruments of prehension are smooth or round on their under sides. The bill, which in these birds is usually called a beak, differs much according to the habit of the owner.

In those which feed upon living prey, that is, prey which themselves have killed, it is furnished with notches and irregularities near the point, which bear some resemblance to the carnivorous teeth of the mammalia, and are perhaps more characteristic of a sanguinary habit and a habit of tearing recent flesh than any other part of the structure. The feet of those birds have all four toes, generally placed three to the front and one to the rear, the inner front and the rear one having the most powerful claws; but in some instances the external one admits of being reversed so as that the toes act two against two; but a foot of this structure is to be regarded as possessing more of the character of a catching and carrying, than a killing instrument.

Birds of prey are conveniently divided into two sections, or families, according to their times of feeding. The first or diurnal family is composed of falcons, hawks, eagles, vultures, with various sub-divisions; and birds of the second division are known by the general name of owls. Of the first family, the falcons are the boldest birds in proportion to their strength; they fly the highest, and kill their prey in the air. The most powerful of them are natives of cold countries, but they are distributed over different parts of the world. The hawks are shorter winged than the falcons, and pursue their game at less elevations in the air; and some birds nearly allied to them, such as the kites, and a few others, glide about with easy flight, and often prey upon reptiles and the very smallest mammalia. The eagles exceed all the others in size and strength, and generally fly high, but seize their prey upon the ground, by descending on it with vast impetuosity. The vultures are more loosely made, and have less powerful beaks and claws than the others; they live in a great measure upon carrion, and are chiefly found in the warm countries, where they act the part of scavengers. Their claws are much less adapted either for killing or for clutching prey than the others; and their chief use appears to be in enabling the birds to retain their hold upon the putrid carcasses on which they feed. The owls fly abroad chiefly in the twilight; and they are remarkable for the fine extremities of their feathers, in consequence of which they fly without making almost any noise. The solid parts of their bodies generally bear but a small proportion to the apparent bulk of the feathers; and though some of those which inhabit the north are very powerful, they are altogether more feeble than the diurnal birds of prey.

Order II. *Passerinæ*, or birds resembling sparrows.—This is an exceedingly numerous order, comprehending most of the wild birds which we observe in ordinary situations, so that the name tells but little, though it is not very easy to select a better. It is divided into a number of groups or sub-orders. *Dentirostres*, or toothed bills, include those birds which feed more exclusively upon insects and small invertebrated animals, though some of them are understood to kill other smaller birds. Thrushes, flycatchers, and most of our summer song birds which feed upon caterpillars belong to this division. *Fissirostres*, or open bills, feed upon insects which they catch on the wing. The different swallows and goat-suckers have this character. *Conirostres* have the bill thick at the base and sharp pointed;

they are, generally speaking, miscellaneous in their feeding. Larks, tits, crows, and many other birds, some of which are remarkable for the brilliant colours of their plumag,e belong to this division. A few sing sweetly, but the voices of the majority are harsh, though many of them may be taught to articulate words. *Tenuirostres* have the bill slender, and their general habit is to pick insects from crevices in the bark of trees, and other places of concealment. Some of them run in all directions upon the bark with the greatest celerity, while others, known by the name of humming-birds, from the noise which they make, crowd the air in warm countries, are often exceedingly brilliant in their plumage, and some species, though perfect birds in all their parts, do not exceed the size of ordinary bees. *Syndactyles*, or equal-toed birds, have the outer and middle front toe of the same length, and both united to each other in the basal part. They are very brilliant birds in their colours; the king-fisher is one of the few British species; and among foreign ones the hornbills are remarkable for a large production of horny matter at the base of the bill, which sometimes stands upward in the shape of a helmet, and at other times projects forward as if it were a second bill on the top of the real one. These are altogether curious birds, and most of them live on animal food of some kind or other; many chasing and catching the large winged insects, and others fishing over the waters.

Order III. *Scansoriæ*, climbing birds.—The birds of this order are chiefly inhabitants of the forests; and we need not add that they are most abundant in the warm parts of the world; because it is there that the forests supply the greatest quantity of birds' food, whether those birds feed on animal matter or on vegetable. They have the feet formed for climbing, or what is called *zygodactylic*, or equally yoked; that is, two toes turned to the front and two to the rear. As is the case with the handed animals, the birds of this order, which are the most expert climbers, are bad walkers, as the joints of their feet turn outward, to enable them to reach and grasp a distant branch with the foot; and many of them make use of the bill as an additional climbing instrument, as some of the handed mammalia make use of their prehensile tails. Woodpeckers, cuckoos, toucans—remarkable for the largeness of their bills; and the almost innumerable race of maccaws, parrots, and parrokeets, which make the tropical forests so gay with their plumage, and so intolerable with their incessant screaming, are examples of this order. In the appearance, feeding, and disposition of these birds there are many differences; but in having the climbing foot they all agree; and, unless it be by accident, there are not many of them that ever alight or walk upon the ground, but they are hatched and live and breed in the trees, though many of them are birds of powerful wing, and can without difficulty make their way from one part of the forest to another.

Order IV. *Gallinidæ*, poultry birds.—These occupy nearly the same relation in the class of birds which ruminant animals occupy in that of the mammalia; and, as is the case with the ruminant mammalia, they are the most useful to man of the whole class. Some of them are domesticated, and others not, while others again live in a state of half-domestication; and in this also they agree with the ruminants. The domesticated ones are the different races of poultry, peacocks, turkeys, guinea-fowl, and common fowl, together with some species not much introduced into Europe, which are domesticated in South America, and which appear to have their native localities rather nearer the water than our poultry. The pheasants are the half-domesticated ones; and the partridges and grouse are those which remain in a state of nature. Still farther to carry the parallel between those birds and the ruminant mammalia, the flesh and eggs of domestic poultry are superior to those of all other domestic birds, just as the flesh and milk of cattle and sheep are superior to those of all other domestic mammalia. In like manner as the wild ruminantia, the deer, and the antelopes, are regarded as the noblest and choicest of four-footed game, even so the wild pheasants, the partridges, and the grouse are esteemed as the best of all winged game in every part of the country where they are found.

Some of the wild races appear to be natives of very cold and elevated countries only, and to adapt themselves to the severe winters on the northern mountain tops by a total change of their plumage from mottled to white, which alters back again from white to mottled in the spring. This is the case with the common ptarmigan, which is not uncommon on the summits of some of the very lofty mountains of Scotland, though rare in the southern part of the island. The partridges, though pretty generally distributed, are natives of warmer climates, and inhabit more low-lying and fertile places; while those races which have been absolutely domesticated are, generally speaking, natives of the tropical forests or their margins; though some of them have followed mankind in their migrations for so many years and into so many variations of climate, that they are broken into endless varieties. The turkey, though the name which it has absurdly got would lead to the supposition that it is a bird from the east, is a native of the temperate parts of America; and so zealous and successful have the American people been in the extermination of it from their forests, that it is rare indeed in a state of nature, especially in the inhabited parts of the country. The peacock is from the forests of India, where numbers are still to be seen in a state of nature; and the common fowl is from the same part of the world. The guinea-fowl is from Africa, in some places of which it is still abundant in a state of nature; and it is said that these birds are so partial to the dwellings of men, that they come voluntarily to the poultry yards in their neighbourhoods and do not readily retire.

The gallinaceous birds agree thus further in their habits with the ruminant mammalia, that the greater number of them are social in their habits, and attached to the society of each other; and that the males are polygamous, or have many females in their train, and fight fierce battles of gallantry about their females. They are not only social with each other, but with all other animals which do not offer injury to them; for, though they chiefly inhabit places where there is plenty of food for them, and thus need few resources, and have, in consequence, no very extraordinary degree of animal sagacity, they are fond of the society of all living creatures; and there have been instances of a solitary domestic hen forming an attachment to a cow, a horse, or a pig, following it into the fields, and being restless and discontented in its absence.

They are all what is called gizzard birds, that is, they have the principal stomach very strong and muscular, for the purpose of grinding vegetable food, and they swallow small pebbles to assist them in this process. But still, they are not exclusively vegetable feeders, but are rather miscellaneous in their eating, and have no objection to worms, insects, caterpillars, and all sorts of animal garbage. In their vegetable feeding, they eat seeds, buds, and fruits, rather than leaves. They are all ground feeders, and their feet are what is called *rasorial*, that is, formed for scraping in the soil in search of anything eatable which may be contained in it; and many of them are partial to rolling or basking in the dry dust. But, though they all feed upon the ground, and the greater part, if not the whole, nestle and rear their broods there, yet all the woodland species roost upon trees during the night.

Few of them make any formal nest; but the females are close sitters upon their eggs, and so courageous in defence of their brood, as not only to drive away birds of prey, but to fly in the face of dogs and other mammalia.

They are very prolific; their broods are numerous; many of them breed twice in the year; and, in a state of domestication, the females continue to produce eggs for a number of weeks, if they are prevented from sitting by the daily removal of the eggs, generally, however, leaving one.

When we contemplate the birds of this order, in their relations to the rest of nature, and the use of man, we cannot avoid feeling that in them, as in the ruminant mammalia, the best bounty of Heaven has been specially meted out to us, and for our good, and, feeling the obligation, can we fail or fall short of the gratitude, without the most just and severe self-condemnation! Somewhat allied to the gallinaceous birds, though different from them in various respects, are the very numerous family of the pigeons. They do not consist of so many different species as the gallinidæ; but they are, in some instances at least, much more numerous in individuals. They are much more vegetable feeders than the others, and are birds of more powerful wing. In almost all the species one male and one female continue attached to each other; and therefore there is no warfare of gallantry among them: but still, some of the species assemble in immense flocks, flocks greatly exceeding those of any other land birds with which we are acquainted. They are birds of powerful wing; and thus in countries subject to seasonal alternations of plenty and scarcity, they migrate in immense numbers, numbers which, in the wilds of North America especially, appear to be beyond all parallel in the history of animated nature. We shall quote a short passage from Wilson, the American ornithologist, in illustration of the immense multitudes and habits of those birds. He is alluding to the western states of America, or those beyond the Alleghany mountains. "These fertile and extensive regions," says Wilson, "abound with the nutritious beech nut, which constitutes the chief food of the wild pigeon. In seasons when these nuts are abundant, corresponding multitudes of pigeons may be confidently expected. It sometimes happens that, having consumed the whole produce of the beech trees in an extensive district, they discover another, at the distance perhaps of sixty or eighty miles, to which they regularly repair every morning, and return as regularly every evening, to their place of general rendezvous, or, as it is usually called, the roosting place. These roosting places are always in the woods, and sometimes occupy a large extent of forest. When they have frequented one of these places for some time, the appearance it exhibits is surprising. The ground is covered to the depth of several inches with their dung; all the tender grass and underwood destroyed; the surface strewed with large limbs of trees, broke down by the weight of the birds clustering one above another: and the trees themselves, for thousands of acres, killed, as completely as if girdled with an axe. The marks of this desolation remain for many years on the spot; and numerous places could be pointed out, where, for several years after, scarce a single vegetable made its appearance. When these roosts are first discovered, the inhabitants, from considerable distances, visit them in the night with guns, clubs, long poles, pots of sulphur, and various other engines of destruction. In a few hours they fill many sacks, and load their horses with them. By the Indians, a pigeon roost, or breeding place, is considered an important source of national profit, and dependence for that season; and all their active ingenuity is exercised on the occasion. The breeding place differs from the former (that is from the settling roosts in the migrations) in its greater extent. In the western countries above mentioned, these are generally in beech woods, and often extend, in nearly a straight line, across the country for a great way. Not far from Shelbyville, in the state of Kentucky, about five years ago, there was one of these breeding places, which stretched through the woods in nearly a north and south direction; was several miles in breadth, and was said to be upwards of forty miles in extent! In this tract, almost every tree was furnished with nests, wherever the branches could accommodate them. The pigeons made their first appearance there about the 10th of April, and left it altogether with their young, before the 25th of May."

There is no migration of pigeons, or perhaps of any other birds, so wonderful as this of the passenger pigeons of America; but if we leave this out of the question, there are some in the eastern parts of the world which are by no means unworthy of notice; and the pigeons there are of more varied species, and some of them birds of far greater beauty than the American ones. Between the islands on the south-east of Asia, and the eastern parts of New Holland, there is annually a great migration of birds. On the line of that migration, the country adjacent to Moreton Bay is a grand rendezvous, as it is a wooded district, and in the season abounds with wild fruits. The pigeons resort to it in vast multitudes; and some of them rival in the brightness of their colours the very gayest of the parrots.

Pigeons, notwithstanding their numbers, have very small broods, only two at a time; but those broods follow each other in very rapid succession; so that from the ardour of their temperament, the great quantity of food which they require, and their continued labour with their broods, pigeons are among the most industrious of all the feathered race. Their handsome forms too, and their attachment to each other and to their young, give them additional interest. But we need hardly say that there is no truth in the often repeated fable of the turtle mourning for her mate, any more than there is in that of the widowed nightingale pouring forth her plaintive notes on a similar occasion. The cooing of the one, and the song of the other, are both uttered by the male birds, and not by the females; and they are both songs of love and not of sorrow. Birds know no sorrow in our sense of the word, and their momentary sounds of alarm are all harsh and screaming.

There is one curious physiological particular in which the pigeons differ from most other birds; their stomachs create a substance bearing some slight resemblance to milk, which they bring up to their bills, and, in part at least, employ in the feeding of their young.

Order V. *Echassiers*, stilt birds or waders.—All the birds of the four orders which we have noticed are to be considered as land birds; for, though some of them resort to more humid places than others, and a few find their food in the water, by descending on the wing for the purpose of fishing, there are none of them that launch themselves upon the water, or even wade, or can bear to have their plumage wet for any length of time. Many of them, no doubt, are much in the habit of bathing or washing themselves; and it is curious to observe some of them, as for instance, the long-winged vultures, spreading out their pinions for the wind to dry them, after having performed this operation.

Some of them too, as for instance those vultures, especially such of them as play the part of scavengers by the margins of the waters in tropical countries, when the seasonal floods begin to subside, have reticulated scales on the tarsi, something similar to those of the birds of this order; but still they are decidedly land birds.

Those which the systematists include in this order, are not all water birds, or even birds of the margins of the waters, dry or humid; for there are some of them which find their food in more arid places than almost any other race of birds. There is not however any way of getting a systematic arrangement of birds, or of any other class of natural productions, which shall in itself be perfectly natural, unless we come to the single species, which would be no arrangement at all; nor could it afford any help to the knowledge of one from the previous knowledge of another; and, therefore, we must submit to the unavoidable anomalies of human systems, which cannot be perfect as applied to the works of Divine wisdom, for the sake of those parts of them that do convey useful knowledge.

Stilt-birds may be distinguished by their naked legs, and generally by the length of the tarsi. These enable them to wade to a considerable depth in the water without wetting their plumage. They all seize their prey with the bill; and, therefore, they have the neck long in proportion to the tarsi. The degree of strength in the bill indicates the peculiar food of these birds. Those which have it hard and strong, are in general fishers, or, if not, scavengers by the margins of the waters; while those which have the bill slender and pliable—and along with this it often has the property of being an organ of touch, by means of which the birds are able to distinguish between what is fit for food and what is not—live upon insects, small molluscous animals and worms. Those which live on dry wastes and do not resort to the waters or their margins, have the bill resembling in part, at least, the bills of the gallinidæ.

The feet of these birds differ much in form. Some, as the ostriches, which inhabit the same arid countries as the camels, have the extremities of their feet something resembling these, with only two toes, and the external one smaller than the other, and without any nail. But as a proof that the feet are adapted to the pasture, the rhea of South America, which runs among tall herbage for a great part of the year, has three toes on the feet, and so have the cassowary of the east, and the emu of New Australia, both of which are on pastures comparatively rich; and the apteryx has the tarsi short, and the feet as much developed as those of a common fowl. These singular birds compose the family of *Brevipennes*, or short wings.

Pressirostres, or those with the bill narrow, and not very long, but strong and pointed, form the next family. They are field birds, swift on the feet, and in some of the species, long on the legs, but some of them frequent the soft grounds near the water. They feed upon earth-worms, ground insects, and larvæ, and sometimes on the seeds of plants. They have the hind toe wanting or very small, and run on the spring of the other toes; a long hind toe is not adapted for rapid motion. This family includes the bustards, plovers, lapwings, oyster catchers, and a few others; all of which are swift-footed birds, and most are also active on the wing.

The *cultrirostral* family, or those with knife-shaped bills, come next. Most of them are large and powerful birds, migrating with the seasons, feeding upon reptiles, fishes, and other animal matters, and acting the part of scavengers in many countries. Their bill and gape are often of great size, and their tarsi and necks are long. Cranes, storks, boat-bills, herons, open-bills, spoon-bills, and some others, are the typical birds of this family. Many of them are very familiar with man, resorting to cities, and perching and sometimes making their nests on the house-tops.

Long-billed birds (*longirostres*) form the next family of this numerous and varied tribe. Their bills are very long and slender, and generally flexible in whole or in part. They are variously formed, being arched downwards in the ibis and curlew, straight in some of the snipes and woodcocks, and turned upwards in the avosets. The ibis genus live by the banks of rivers and feed upon reptiles; the others come gradually nearer the water, and seek their food in softer ground in proportion as their bills are more tender and sentient. The avosets bring the succession down to the shallow runs of water, from which they scoop their food in a curious manner. These birds are the true marsh birds, and some of them are accounted delicacies for the table.

The long-toed birds (*macrodactyles*) form the last regular family of wading birds. Their long toes fit them for walking upon aquatic plants, and some on the water itself. Most of them have partial webs uniting their toes at their bases, and some of them have the toes margined for the whole length. They consist of rails, water hens, coots, and several birds, chiefly American, in which the toes are remarkably long. They live and nestle in the tall herbage by the banks of streams and pools, their habits are retiring, and most of them can make their escape by running partly on and partly in the water. The form of their bodies is well fitted for making way through tangled vegetation; and their long toes give them a footing on grass and other herbage, where it is difficult for any other animal to follow them.

There are some curious birds, of which the place in the system is not very apparent, which are usually placed here; and all of them frequent the margins of the waters. The carrion bird of New Holland, which is about the size of a partridge, black, with a sort of sheath on the basal part of the bill; the pratincoles, which are handsome birds, remarkable for the length of their wings and the swiftness of their flight; and the flamingos, which have legs and necks of immense length, and are remarkable for their bright red colour, are the principal birds of those genera which do not connect themselves very naturally with any of the groups or families.

Order VI. *Palmipedes*, web-footed or swimming birds.—While the birds of the preceding order form a sort of intermediate inhabitants between the land and the water, those of the present order bring us upon the broad waters themselves, and thus their feet have a new function to perform, that of rowing them along. But though the water is one substance, and does not present the same variety of surface as the land, and therefore does not need the same almost innumerable variations in the structure of a foot adapted to it, yet there are other functions to be performed by the feet of those birds; and those functions require a different structure than if the feet were formed for swimming only. All water birds necessarily breed, and many of them repose upon, the land; and there are several that advance a considerable way inland for the purpose of breeding, and which, though they form their nests in tufts and bushes near the water, range over the fields in quest of their food. The way in which those swimming birds arrive at the water, or change their localities in it, is perhaps their best distinctions.

There are some which dive through the free waters, remaining under the surface for a considerable time without wetting their plumage. These are correctly enough called divers, though they are not the only birds which dive. They, however, invariably dive when they are to catch their food, not to the bottom, as is the case with some of the ducks, for they catch their prey by a snap of a hard bill, which is often toothed that it may retain its hold the better, and do not dabble or feel for their food as the ducks do. In general they are short winged birds, and some of them have the wings so small as to be incapable of flight; while their legs are all placed so far backwards that they are very bad walkers. Hence, perhaps, they are the most exclusively water birds of the whole order. Grebes, divers, guillemots, penguins, and several others, belong to this well-defined family, some of the last being wholly incapable of flight.

The next order, *Longipennes*, or long wings, are, as water birds, the very reverse of the former, though like them they find their food in the free waters. They are among the best winged of all birds in proportion to the weight of their bodies. The numbers of some of them are astonishing, and they are met with far from any land; and some are so rarely found there as to appear absolute inhabitants of the wide seas. There are revolving currents of wide extent in some parts of the ocean, especially in the Atlantic, a great quantity of sea weed, and little fishes, and other small animals, collect in those parts; and there are tropical birds, man-of-war birds, and others, with their flying feathers remarkably produced, which are found over such places. Petrels are generally distributed over the surface of the water, some of them feeding on the oil with which that surface generally abounds; gulls are well known on the shores of most countries; and terns skim the surface of the ocean with a style of flight not very unlike that of the swallows upon land.

The birds with all the four toes included in the web, which we mentioned as not being exactly swimming birds, descend from the air in plunges upon their prey; but though they can float about, and sometimes do feed when in that situation, their proper motion is on the wing. Pelicans, cormorants, tropical birds, and a few others, belong to this family.

The last family of the order have the bills flat, and in many they are covered or margined with a sentient membrane, so that the animals can feel for their food. As they seldom take the wing, except in their migrations, they may be considered as more particularly birds of the shores and shallows. They stand nearly in the same relation to the rest of the water birds, as the poultry stand to the other land birds, or as the ruminant animals stand to the other mammalia. Some are vegetable feeders, as geese and swans, others are miscellaneous feeders, as the common ducks, and others feed more exclusively on animal matters found at the bottoms of the shallow waters, as is the case with the diving ducks.

Such is a mere outline of the feathered race, in their distinctions from each other, in their distribution over the land and the waters, in their general habits, and in the more remarkable structures which fit them for those habits. From the universal action which those animals have, from the great energy of many of them, from their commanding the air, the land, and the sea, to an extent to which all the three are not commanded by any other race of animals, from the beauty of their forms, the richness of their colourings, the wonderful perfection of mechanical design and execution which they display, from the singular powers of endurance which some of them possess; and from the almost countless number and variety of instincts, which guide to the places best adapted for them, and often induce them to pass from beyond the equator to the regions of the extreme north, ere the sun has apparently twice girdled the heavens, they form one of the most inviting, one of the most lovely, and one of the most instructive pages in the wonderful volume of that creation which the bountiful Author has opened wide to all His rational creatures; and who has so ordained, that in proportion to their knowledge of this volume shall be the measure of their true moral enjoyment.

CHAPTER VI.

REPTILES.

1. In the class of reptiles we find not a less display certainly of the wisdom and the power of the Creator, for all the works which he has made are alike perfect in their several kinds, but in them we find that wisdom and power so differently displayed, that we are led equally to admire the endless variety of means by which ends can be accomplished, and the perfect manner in which every one of those varied means is adapted to its respective end.

In both their systems, the vital or vegetative one, and the sentient or animal, the reptiles are much less imperfectly developed than either the mammalia or the birds. In those two classes the more important functions of life are very similar to each other, though the organs differ in form according to the other habits of the creatures. So that when we once understand how the functions of circulation and breathing are carried on in them, the knowledge thus obtained serves us through all the mammalia and all the birds; for down to the very humblest member of either of those classes, the double heart, the passage of all the blood through the lungs, the constant exertion of a comparatively high degree of action in the system, varying in the individual and species no doubt, but still similar in kind, run through the whole.

When, however, we come to the reptiles, we find that those fundamental operations of the animal system are less perfect; thus the heart is only partially double in the best developed ones, and that in those which are the least so, it approaches to the single heart of the fishes; and it is not unworthy of remark, as showing the uniformity and simplicity which run through the whole works of creation, that those reptiles which have the nearest approach to fishes in the structure of the heart, have the habits and the element of fishes in the early stage of their existence, being then inhabitants of the waters, and breathing by the means of gills.

In consequence of this, the blood of the reptiles, though red in the colour—as it is in all vertebrated animals how imperfect soever may be their development, is cold and small in quantity, as compared with that in mammalia and birds. The animals are, in consequence, languid in their general motions, though capable of great exertions at particular times; and because they have not sufficient action in themselves to generate even that degree of heat which is required for the comfortable existence of such as dwell in warm climates, these are much more confined in their range than the mammalia, and the birds of the same climates.

In the older systems of natural history, and up to a comparatively recent period, those animals were called *Amphibia*, by which was understood the capacity of living indiscriminately on land and in the water, and not only living in the latter, which is done by many mammalia and birds, but actually breathing water in the same manner as fishes. This is not true of any species, at least at one and the same time, though some of the lowest of the *Batrachian*, or frog-like reptiles, have so close a resemblance to fishes, that it is not very easy to draw the line of distinction between them; and it is worthy of remark that reptiles of this order whether they change from that aquatic habit which they have in the early stages of their being, or continue in the doubtful state of the obscure species just alluded to, are produced in a manner somewhat resembling the production of fishes, while the more perfect reptiles more resemble birds in their mode of production.

In their general appearance and also in their habits those animals have not much to recommend them to the attention of mankind. Few of them are either handsome in shape or gay in colour; and, setting all prejudice, allegory, and fable aside, there are points connected with the characters of some of them which are not a little repugnant to our feelings. Some reptiles are armed with a most deadly poison, a substance of which there is no vestige in mammalia or birds; and others pursue their prey with the most cold and unrelenting ferocity, and are objects of terror in consequence of their great strength and the savage use which they make of it. The greater number are, however, on the other hand, perfectly harmless, and some of them are active and playful, and capable of forming attachments to human beings. In the cold and temperate latitudes there is no reptile at all formidable from its strength, or dangerous from its poison; and in temperate countries the numbers are very few; but some of the serpent tribe are poisonous, and prejudice has transferred this dangerous property to everything in the shape of a snake, and even to the common toad, which, except to the insects on which it feeds, and in the eating of which it does no small service to man, is one of the most passive and harmless creatures in existence.

We have said that, in consequence of the small power which they have of generating heat, reptiles are almost as passive to changes of temperature as if they were not possessed of life; and, though there are abundance of frogs in our humid meadows in the summer, though toads crawl about toward evening after rain, and newts move more nimbly in moist places, yet after the cold weather sets in not a single reptile is to be seen.

Now, it is a fact worthy of observation that the power of endurance and of preserving life under states of prolonged privation, is as remarkable in these animals as their passiveness to the vicissitudes of the seasons. When we say passiveness to the seasons, we must not be understood as implying that the animals can bear seasonal changes without being much affected by them; for the very reverse is the case,—they have little power of resistance; and therefore the weather commands them, while those animals which are better developed and have more resources, can command the weather, and preserve their vigour equally under the summer sun and amid the winter snow. Reptiles can bear hunger for a long time, without any apparent loss of substance; their heart will continue to beat for several hours after it is separated from the body, and the body will perform its motions after the heart is taken out; and though the animal is divided in pieces, each piece will continue to move for a considerable time. Farther than this, those reptiles which have extended members to their bodies, such as feet and tails, can, in many instances, recover these if removed by accident, which is a power not possessed by any of the mammalia or birds. They live equally long without the brain as without the heart; and respiration appears to have so little connexion with the slow circulation of their blood, that most of them can remain much longer under water than even the diving birds, and the cetaceous mammalia; and also upon land they can suspend their respiration, and, if circumstances so act upon them, let down their slow circulation to the close confines of absolute death, and yet revive again under the influence of a beaming sun and a warm atmosphere.

Reptiles are an obscure race of animals, and their manners have been much less observed, and their history much less studied, and its parts much less connected with general principles, than is the case of any other vertebrated animals. But from the few particulars above stated we shall perhaps be enabled to get at least a glimmering at what their use is in creation. There are certain places, especially in warm countries, where the alternations of the seasons are so great, where the atmosphere is so impure and rank, and where the whole circumstances are perfectly unfit for the habitation of a mammiferous animal or a bird. Many of those loathsome places are also so thick and matted with branches, with grass, and with accumulated weed and leaves, that no bird and none of the mammalia could make way through. Those places to which we allude lie in regions where the seasons are extreme, where the flood covering the ground to a considerable depth often instantly follows the drought, and where, at other times, the water is dried up with almost equal speed: Such places are as unfit for fishes as they are for the two higher classes of animals; and yet, from the very structure of the earth, its motions, and the action of the sun upon it, there must not only be such places, in order that the system of the whole may be perfect, but these must be places of extreme production; and therefore to prevent the productive power from being choked and destroyed by the fruits of its own wokring, it becomes necessary that there should be a peculiar class of beings formed for such places—beings which, obedient to external action, as we have said the reptiles are, should obey the sun and the physical circumstances of the earth during all the variations of the changeful year; and this is exactly the office for which the more powerful reptiles are especially fitted. Inhabiting the land or the waters of those regions which are the most rich and rank, the most powerful of these creatures are called into great vigour by the action of the sun; and they consume that which, but for them, would die, and rot, and breed pestilence, at the turn of the year, when the great power which called it into existence had ceased to operate. No doubt the animals of this class, like those of all other classes, have great shades of difference from each other, and in the extreme points make slight approaches to animals of other classes; but in the more characteristic species they answer the description which we have given; and our limits forbid us from entering further into particulars.

Reptiles, which vary much in their structures, and not a little in their habits, are divided into four orders: tortoises (*chelonia*), lizards (*sauria*), serpents (*ophidia*), and frogs, and frog-like animals (*batrachia*).

2. Order I. *Tortoises, or chelonia.*—The animals of this order are perhaps the best developed of all the reptiles, though they are creatures of very singular appearance. They have a short, thick, and oval shaped body, covered with a shell of a peculiar kind of horny substance, or with a tough membranous integument. In the case of a shell, there are two distinct portions, the shield on the back of the animal, and the breast-plate on the under side. The shield is so united to the vertebræ of the back, and to the ribs, as that there is no motion in these parts. The breast-plate is fastened to the other by a sort of ribs, which are however of membranous texture. This breastplate may be considered as representing the sternum or breast-bone; and in this part of their anatomy the animals so far approximate those crustacea who have their skeletons on the outside, that the blade bones of the fore legs are placed on the under sides of the ribs and not on the upper. In some of the species this covering is of great strength, and quite prevents all motion in those parts of which it forms the basis, so that there is no heaving and depression of the chest in the process of breathing as there is in mammalia, nor of the abdomen as there is in birds. The muscles which assist in compressing the lungs and allowing them to expand are inserted on the shield and the legs, and their action is very slow, so that the animals rather take a continued draught of the air than receive it by a regular inhalation. The only parts of the body which are capable of motion, are the head, the tail, and the fore legs. The articulation of the different vertebræ of the neck is often very curious; and there is no arti-

culated bone capable of such varied motions in an equal length, as that of the neck of a short-necked tortoise. The circulation is peculiar, consisting of an imperfectly formed heart, and its connecting vessels. There are two auricles to this heart, the right one receiving the blood from the body, and the left one that from the lungs; but there is only one ventricle for the propulsion of the blood from the heart, which propulsion is the essential act of circulation. It is true that this ventricle is partially divided by a partition, but the two parts communicate with each other, and thus the blood which has been at the lungs and undergone the action of the air there, mingles with the rest of the blood, and the two together are sent over the body. How much or how little of the blood requires to be acted on by the lungs before it is fit for circulation in the more active states of the animals has not yet been determined; and it is probable that when they are in a state of inaction, the circulation may go on and life continue, without any breathing, for days, for weeks, or for months. The ordinary breathing is performed by means of the mouth, and the action of receiving the air has more resemblance to drinking than to breathing. The jaws being closed, the tongue is lowered, a cavity is formed, and the air fills this cavity by entering through the nostrils. The tongue is then raised first to close the nostrils, and then to obliterate the cavity; and thus the air is forced into the lungs. Tortoises have no teeth, but have the jaws covered with a horny substance, not unlike the bill of birds, though in some of the species they are covered with a tough skin only. The females produce a number of eggs, upon which they never sit, but leave them to be hatched by external nature. Those eggs have a slight flavour of musk; but they are in general eatable, even in those species of which the flesh is not pleasant. Tortoises are found only in countries where the heat is above the average, some of them on land, some in the sea, and some in the fresh waters. They are very slow in their motions; and, as their bones are less perfectly formed than those of mammalia and birds, they live to a great age, and continue growing during the whole time. Most of the land ones bury themselves in the ground during the cold season; and though they do this very slowly, their labours are very sure. These animals are found in the south of Europe, and in many of the warmer parts of the world, and in India and some other countries they grow to a very large size.

Many inhabit the fresh waters, and these have webbed feet adapted for swimming. Some of the smaller species are found in the rivers of continental Europe; but those of America are much larger and handsomer. These, like the land ones, are covered with shields of considerable strength; and some have the breast plate jointed, and can withdraw their head and feet entirely within the shell, they being distinguished by the name of box tortoises.

The species which inhabit the sea are by far the largest: and of them the most celebrated as an article of food is the green tortoise, known by the name of turtle, which name is applied to all the sea ones. It is very abundant in the seas of warm latitudes, both in the east and west: and it has been known as an article of food since the time of the Romans. It can be brought alive without food from a distance of two thousand miles or more; and some specimens are of such dimensions as to weigh no less than eight hundred pounds. The eggs are also much esteemed; and the flesh is accounted exceedingly nutritious. These animals feed on aquatic plants, and are so plentiful, that in the markets of warm countries their flesh is as abundant and cheap as that of ruminant animals in Europe.

The hawksbill turtle is a more active species than the former, of little value as food, but furnishing the tortoise shell of commerce which is so much used in the arts. There is no turtle in the sea so far to the northward as Britain; but there is one not uncommon in the Mediterranean, which is very large and active, rather coarse and oily as food, but furnishing a thin shell without much beauty of colour, which cabinet makers often use upon coloured grounds instead of the genuine shell of the hawksbill.

Some of the animals of this order have a soft or leathery covering, and some of these, especially one which inhabits the muddy rivers in the south parts of North America, are very ferocious, preying indiscriminately upon birds, fishes, and less powerful reptiles. Tortoises are altogether singular animals, and the land ones especially are perfect models of patience and endurance.

3. Order II. *Lizards—Sauria*, or tailed reptiles.—Like the tortoises, these are found only in the warmer parts of the world; and as is the case with them, the more powerful species are found in the water. But the species are far more numerous; some of them are very active animals; and a few

are furnished with membranes, by the help of which they can perform a sort of flight.

Their heart and whole circulating system are very similar to those of the tortoises, and like them they are all produced from eggs. None of them sit upon their eggs for the purpose of hatching them, but there are some species in which the females watch them with considerable care. Their skins are generally covered with horny scales, which are minute grains in some, and large and strong shields in others.

These animals have a power of moving the ribs, although they have no diaphragm, and thus their breathing is more complete than it is in the tortoises. Many have the lungs descending far into the cavity of the body (for reptiles having no diaphragm have no separation of chest and belly), and those which have this prolongation of the lungs change the colours of their skins when they are differently affected, often in a very singular manner; but the uses of these changes, and also of the various inflations of membranes in different species, are not known.

The young always issue from the eggs in that form which they are to have through life; but the size, when they issue, is often very widely different from that which they afterwards attain. The egg of the crocodile is, for instance, not larger than that of a goose, and yet the full-grown animal reaches the length of not less than thirty feet, and measures fully five feet in circumference at the thickest part.

The eggs of the saurian reptiles are covered with shells of considerable hardness; but they are easily distinguished from the eggs of birds, by the parchment-like texture of the coat, the possibility of dimpling it without fracture, and the equal thickness of the two ends. The animals have generally four legs, though sometimes only two; they have usually five toes armed with claws, and often great power of holding on with the feet, so that the lighter ones can run perpendicularly as with the back undermost; but their feet and legs have an awkward appearance, as compared with those of the mammalia; and their tails, which are often long, are always very thick at the basal part, and have the appearance of a continuation of the body, as if the animal were a serpent mounted on feet.

Of crocodiles, there are several species, bearing a considerable resemblance to each other, and found only in the great rivers of the warmer parts of the world. Their ferocity and power have been both very much exaggerated, but still they are animals of no small strength and daring. They have the tail compressed laterally, so that by its motion from side to side, it assists them in making their way through the water. They have five toes on the fore feet and four on the hind ones, but only three on each foot are furnished with claws. The jaws are very long, and each armed with a single row of powerful but ragged teeth; they have, however, no character as teeth, and are neither carnivorous nor anything else, according as the teeth of the mammalia are estimated: they are merely spikes affixed to the jaw. The gape of the crocodiles is wide; and though they have not, as was long supposed, any proper motion of the upper jaw; yet, as the articulation of the jaws is part of the skull, they, when they open the mouth widely, always raise the head upwards and backwards, which gives the same appearance as if the jaws parted from each other by a motion of each. Their mouths are not only unfit for mastication, or for any other purpose than that of simply seizing their prey, but they are incapable of swallowing prey in the water, or any large prey even on land, so that they take their larger prey under the water and devour it, and often leave it in the mud till it becomes putrid. The species found in the Ganges is called the gavial, that of the Nile, and some other African rivers, the crocodile, and those of the American rivers, caimans, or alligators. There are varieties of most of them, but the habits of all are very nearly alike.

The other sauria are so very numerous and diversified, that the mere names of them would occupy much space. The greater number of them feed upon insects, some catching them by speed, others by lying in wait, and others again by means of the viscid matter with which their extensile tongues are covered. Some of them are diurnal and others nocturnal. The number of insects which they destroy is almost incredible, and as insects are the real pests of man in the hot climates, the services which the different species of lizards render to him are far from unimportant, independently of their use in free nature, in preserving the balance of the races of beings in situations where this could hardly be done by any other known means. These saurian reptiles appear uncouth creatures to us. accustomed as we are to the sight chiefly of mammalia or four-footed creatures, and there are many parts of their curious bodies of the uses of which we are ignorant; but we must not make our ignorance the measure of usefulness in nature, but rather extend the sphere of our inquiries; for we may rest assured that there is a lesson of wisdom, not only in every creature which God has made, but in every organ and part of every creature. The produced membranes, the skin capable of inflation, the singularly formed eyes and feet, and all the other parts different from what we observe in the animals of our own country, which we meet with in those haunts of the sunny lands, must all have their purposes in that beautiful system of creation, where nothing has been made in vain; and instead of idly wondering at them we but establish our claim to that rank which our Maker has been pleased to assign us, when we examine them all with reverence, and contemplate them with an eye to the increase of knowledge.

4. Order III. *Ophidian reptiles, serpents.*—These are the species, or rather this is the order to which the name reptile strictly and properly applies; and they are the ones on account of which the prejudice to which we have alluded appears to have been taken up against this very curious, and generally speaking, very harmless class of animals. The ophidian reptiles have no external feet; and many of them have scarcely any rudiments of those internal bones to which the feet of animals are usually attached. It is among them, too, that the species armed with deadly venom are found; for though some of the saurian reptiles discharge secretions from certain pores of their bodies, which impart a deleterious quality to provisions over which they pass; yet there is no vertebrated animal armed with a poisoning tooth, except some of

the ophidian reptiles. We sometimes read of the stings of serpents, but there is no vertebrated animal provided with a sting; and though various spines and sharp projections from the bodies of such animals, and, among the rest, the antlers or sharp branches of the horns of deer, have been supposed capable of inflicting poisoned wounds, the probability is, that the imagined poisoning is nothing more than the greater degree of pain and systematic derangement produced by a ragged wound; and we often find that a wound inflicted by a rusty nail, and even by a clean knife, in some parts of the body, will bring on disease which is as fatal as the most deadly poison of any serpent.

The poisonous serpents form but a small part of the whole; their poison appears to be given them as a sort of substitute for mechanical strength; the most deadly ones are chiefly confined to wild places in the warmer regions of the world, and they are animals remarkable for the general peaceableness of their dispositions, the concealment in which they live, and the rare instances in which they do harm to man or to the larger mammalia. They live lives of indolence, seldom come abroad, and very seldom eat; and probably there is no instance of a human being having received hurt from one of them, except through carelessness, or foolhardiness, in attacking the creature without knowing the proper means of defence against it.

Serpents are conveniently arranged into two divisions, those which have the scales on the upper and under parts of the body alike; and those which have them different. The former division are never poisonous, and some of them are very handsome animals. The first division have, generally speaking, some vestiges of shoulder bones; and the common snakes, which are most inoffensive creatures, have the ribs nearly encircling the body; and they walk by means of the flexures of the body, without any immediate advantage from the scales on the belly acting as feet. These serpents have the teeth small and nearly of equal size; and some of them have the muscles so irritable that the animal breaks in pieces by a very slight blow, if that blow is given when it is in a state of excitement. The greater number of these are oviparous, that is, produced from eggs; but there are a few which it is understood hatch their eggs internally.

Serpents of the second division have the scales on the under part of the body differently formed from those on the upper; and those scales on the under part are so united to the ribs, as that the rib forms a kind of leg, and the scale a sort of foot, by means of which a curious gliding motion is performed. These are the true serpents, and they are remarkable for the extent to which the jaws can be opened and the gullet distended, so that the animal can swallow and digest prey several times larger in diameter than its own body. This distension of the mouth is produced partly by the introduction of a bone intermediate between the lower jaw and the skull, and partly by the elasticity of the substance by which the bones are united.

Those serpents admit of division into such as are armed with no poison, and such as are so formed. The smaller ones of the first division live upon prey of moderate size, and have the mouth well furnished with teeth; four rows in the upper jaw and three in the under, are the regular number in those true serpents which are not poisonous. Some of the larger ones are animals of vast power, and, though their exertions of strength are momentary as compared with those of many other animals, they are very great while they last.

The boa of the rich and humid districts by the banks of rivers in tropical America, and the python of places nearly similar in the south-east of Asia, and especially in the south-eastern islands, are the more formidable of those crushing serpents; and some of them are stated to have attained the enormous length of from thirty to forty feet, while the folds into which they can compress their bodies are sufficient to crush the hardest bones. Many of the stories repeated of them are no doubt incorrect; but still they are formidable animals. The chief specific distinction between the boa of America, and the python of the Asiatic islands, consists in the boa having one row of scaly plates on the under side of the tail, and the python two rows. Powerful as those serpents are, they do not poison, neither do they give a deadly bite; for their teeth are so constructed as to assist in the operation of swallowing only. Of the poisonous serpents, some have no common teeth in the upper jaw, but merely a fang or poison tooth on each side; but there are others in which there are common teeth in the upper jaw behind the poison teeth. One of the most deadly of the poisonous species is the bushmaster of tropical America, but like the allied species, the common rattle snake of North America, it is seldom if ever the first to make the attack on any larger animal. The smell of those very large poisonous serpents is said to be so offensive as to give notice of their presence to human beings or other animals which go near their hiding places in the thick bushes of the tropical forests. In other parts of the world the poisonous snakes are not quite so formidable in size as the American ones; but some of the smaller ones of very hot countries are deadly in proportion to their size. The greater number of the true serpents are expert swimmers, and readily take to the water; and a number of those which have common teeth in the upper jaw in addition to the poison fangs, are aquatic in their habits. It must not be understood, however, that they are animals which breathe under water, for all serpents, whatever may be the place of their common habitation, are breathers of air by means of their lungs. The greater number of the true serpents hatch their eggs internally, or are what is called *ovoviviparous*, that is, produce their young from eggs, and also bring them forth alive. This is the case with the common viper, which is found in some wild and neglected spots of England, though not nearly so common now as when the country was less cultivated; but though vipers and most others of the division bring forth their young alive, the common story is not true that they swallow their young when danger appears, and discharge them forth again from the mouth when the danger is over. This is quite inconsistent with the general physiology of the whole race of the true serpents. Those animals, whether furnished with poison fangs or not, have the digestive power so strong and extending so far up, even to the mouth end of the gullet, that the moment any substance is taken in there, it is not only dead, but in progress of being decomposed; and thus a female viper or any other true serpent could not possibly swallow her young without at the same time making a meal of them.

Serpents, in all their varieties, offer singular subjects of contemplation to the reflecting student of the works of nature; but their haunts are of difficult access, their habits are so obscure, their powers are in some instances really so dangerous, and in other instances they have been so beset with imaginary danger, that less is known of them than of any other living creatures, and far less than the very singular powers with which they are armed, and the very singular parts which they play in the great working of nature, seem justly to deserve.

5. Order IV.—*Batrachia*, frogs and frog-like animals.—Reptiles of this order differ from those of the other three orders in many points both of their structure and their economy. They have but one auricle as well as one ventricle to the heart; their breathing is even more limited, and their blood colder than that of the others: they have, generally speaking, two equal lungs in the mature or adult state; but in the earlier stages they have gills bearing some resemblance to the gills of fishes, placed like these on arches of bone, or cartilages attached to the os hyoides, and covered by a gill-lid, which, however, is in most of the species absorbed as well as the gills are, when the animals change from the young to the perfect state. There are, however, three curious genera, *siren*, *proteus*, and *menobranchus*, which appear to retain the gills during the whole period of their lives; but the manners of those singular animals are very obscure. Some of them pass the greater

part of their lives not only in the waters, but in subterraneous waters which are nearly cut off from the air and light. While the gills remain, the artery proceeding from the heart divides into as many branches as there are gills, and the veins from the gills unite, and convey their contents to a dorsal tunicle, which, something like the vena porta, which supplies the liver in man, is a vein at the receiving end and an artery at the other. From this the systematic arteries branch off, which carry the blood over the body; and the systematic veins bring it back again to the auricle of the single heart. The dorsal vessel is thus the subcuticle for the systematic side of the head in mammalia and birds; and this is also the case in the circulation of fishes.

In those species which have the gills during their change from the young to the perfect state, all the vessels which supplied the gills become obliterated except two, and these go to the two lobes of the lungs; the other parts of the circulation remaining much the same as before, only the structure of the body itself is different.

Those reptiles have no shield or breast-plate like the chelonia, neither are they covered with scales as is the case with many of the second and third orders. The integument of their body is, in all cases, a naked skin; and so little is their system disposed to the production of hard matter, that out of the many which are found, in almost every part of the world, there is only one which has claws on the toes.

The eggs of the batrachia have some resemblance to the spawn of fishes. They are in clusters or in chains; and, in many instances, they are not fecundated till in the act of passing from the body of the female. They are wholly gelatinous, and without the slightest vestige of a shell of hard matter; nor do the parent animals take the least concern in the hatching of them.

The young not only have gills and live in the water, but they have produced mandibles and a tail something like the hinder part of a fish. In this stage the young of the common species are called tadpoles; but after a time the feet make their appearance, and soon afterwards the fish-like parts disappear. In one American species, the tadpole is so large in proportion to the frog, that it was long supposed that the change went the other way, by the frog being changed to a fish, which, however, is not the case.

It is worthy of remark here, as a general law of the whole living world, that when, by any of those causes of monstrosity for which we are unable to account, any one individual happens to deviate from the common form or type of its kind, the deviation is always a falling short and never an exceeding of that type; and, in the case of those animals that undergo transformations, of which there are remarkable instances in some of the invertebrated animals, the young in their untransformed stage are always lower in development than the transformed and mature ones.

This is a portion of the philosophy of nature which is equally fraught with wonder and with instruction, and calculated to force upon us, even should we vainly attempt to resist it, the grand truth of the being of a creating and preserving God. If, indeed, those other proofs of this awful but delightful truth, which are set forth in the whole works of creation, and all their laws and changes, which lie thicker than "the leaves in Vallambrosa," were destroyed; or if man should become "deaf as the adder" to their voice; there is that in this one which no mind of the least candour and discernment could possibly resist.

Considered as mere matter, and possessing the qualities of mere matter, there is hardly a shade of difference which the most lynx-eyed observer can detect between the matter which composes a man and a monkey; and there is very little difference in these respects between the matter which forms either of these, and that which forms the humblest reptile. Now, if these were only the properties of matter, or matters of fact in every case and in all cases, why should there be a pause at any one of these types, beyond which the matter that has once assumed this type cannot go? In the material world, sophistry itself cannot find a single line in the way of this progress. But all nature proclaims that there is a bar; and therefore this bar is independent of the properties of matter, superior in power, and capable of controlling them. Nor can we find any origin for this, but in the power and the pleasure of a creating God, all-wise and almighty; and the law which determines every creature after its kind, is as much a work of creation, and as independent of the laws of dead matter, or of the substance of that matter considered merely as such, as the years beyond the flood are of the years which have not yet arrived.

The animals which compose the batrachian order are frogs, toads, salamanders of the land and the water, amphiumas, axoloti, menobranchi, protei, and sirens; for the last of which there are no appropriate English names.

The frogs and toads are well known from the native species; but there are some of the foreign species which have very singular economy in their mode of production. The eggs are placed by the male on the back of the female, where they form little cells, and are hatched and quickened there till the tadpoles are able to take to the water.

The salamanders have long tails, and thus they are saurians in their mere form, but they are true batrachians in all their essential characters. It is worthy of remark that these batrachian reptiles have got the name of a fabled animal which could live in the fire, which animal never had, nor probably could have, any real existence; whereas the nature of most batrachian reptiles is such that they could not live in a medium so warm as the temperature of health in the human body. Some of these animals occur in Europe; but they are much more numerous in America.

The amphiumas have the feet very short, with three toes upon each, and the body long and slender. They have their gills in the perfect state.

The axaloti retain their gills, in the form of long tufts; at least, this much is said of them. It is an animal but little known, and found only in the lakes near Mexico.

Proteus is about a foot long and as thick as the human finger. It has hitherto been found only in some of the subterranean passages by which the very singular lakes in the south part of Austria communicate with each other. It has four legs, but they are very small, and its eyes are so minute and so much covered by the skin that they are hardly visible.

The sirens are the last and the most singular of the whole order. They are formed something like eels, and have three tufts of gills; they have small fore feet, but not a vestige of hind ones. Some have maintained that they are the young of another race, as, for instance, of the salamanders; but their bones have the consistency of those of perfect animals, which is not the case with those of the newly-formed young of any species of batrachia. They inhabit the marshes of the warmer parts of North America, and feed upon worms and other small animals. There are several species, and some of them attain the length of nearly three feet.

Such is a very short outline of the reptiles, animals which are inferior in their development, but so well adapted to their places in nature as to force us to declare—"In wisdom hast thou made them all."

CHAPTER VI.

FISHES.

These form the last class of vertebrated animals; and although from the nature of their habitation they are in a great measure concealed from the common observation of human beings, yet they are not the least wonderful of the works of God, or the least demonstrative of that wisdom, power, and goodness, of which the whole creation is one continued proof. The waters, which are the proper habitation of the fishes, occupy, including the oceans and seas, and the fresh waters which adorn and fertilise the land, about three fourths of the whole surface of the globe which we inhabit; and as these waters are fertile in their depth and not in their mere surface, their productive powers bear a much higher proportion to their mere extent than the productive powers of the land.

Other circumstances, besides a more ample and extended pasture, confer advantages upon those animals which inhabit the waters, and can breathe and perform all the other functions of their economy under the surface. They are comparatively little affected by the changes of seasons and of the weather. Until we reach the very extremes of latitude, the difference of temperature in the water at different seasons is not great; and even under the ice the temperature is never so low as it is in the air during the nights of the spring and the autumn, even in our temperate latitudes. The most violent storms, which lash the surface of the ocean waters into mountain waves, do not disturb the tranquillity of the deep beyond a few fathoms. The element in which the fishes reside is so nearly of the same specific gravity as their bodies, that they have little weight to carry. Thus fishes dwell more at their ease than any inhabitants of the land; and growing, swallowing and digesting their food, and continuing their races, in which last their fertility is truly astonishing, are the only tasks that are imposed upon them. With few exceptions, they have no provision to make for their offspring; and as many (probably the greater number) are exempted from decay, they increase and multiply, and fill the mighty volume of the waters to such an extent that the most fertile places of the land are barren and tenantless in comparison.

Fish breathe air through the medium of water; and though they have only a single heart, they have a double circulation. Their breathing apparatus are gills, or fibres, attached to arches of bone on each side of the neck. The action of the mouth of the fish receives the water, which passes through the gill fringes, and is discharged by the action of the gill covers. In the meanwhile the heart, which answers to the right side of that in mammalia and birds, sends the blood to the gills, where it undergoes the necessary action of the air contained in the water; after which it is carried to an arterial trunk situated on the spine. This acts as a systematic ventricle, and sends the blood all over the body, from which the veins bring it back to the heart, whence it is again sent to the gills.

Fishes have the whole body adapted for progressive motion through the water, the principal organ in the performance of which is the tail or caudal fin, but the greater part of the muscles of the body conduce to the same purpose. The chief motion of the spine of a fish is horizontal. The tail striking the water right and left, which is contrary to the principal motion of the spine in other vertebrated animals. There are, however, other fins, which have some slight resemblance to the legs of mammalia. Those which answer to the fore legs are called pectoral fins, and those which answer to the hind legs ventral fins; but the last vary in their position, and in some genera they are wholly wanting. There are also fins on the back, which are called dorsal, and on the under part of the body backwards, which are called anal.

The dorsal and anal fins are placed on the same plane with the caudal or grand propelling fin, and they act along with that, either in directly adding to the lateral force of its stroke, or giving it a fulcrum of resistance. The pectoral fins and the ventrals, where the latter exist, are placed across the plane of the caudal; they are thus chiefly used in ascending and descending motions; and their place, in the case of the ventrals, or their absence, are the characters, which, in part at least, guide us to the habits of the fish. Fishes which swim near the surface generally have the ventral fins placed far backwards, while those which feed in the depths have them on the fore-part of the body; and in those which are, properly speaking, bottom fishes, the ventral fins are wanting.

The fins of fishes consist of membranes spread out upon rays; and there are some not unimportant distinctions of the animals founded on the characters of these. If the rays consist of a single pair each, which is more or less stiff and elastic, they are called spinous, and the fishes which have them are called *acanthopterygii*, which means having fins with spinous rays. If the rays are formed as a number of jointed pieces, whether of greater or less consistency, the fishes are called *malacopterygii*, which means that they have the rays of the fins jointed or articulated, or that, in consequence of these joints in the rays, the fins are soft and flexible.

The bones of fishes do not contain so much earthy matter as those of warm-blooded animals;

and even in those that have much of the bony character in their skeletons, the vertebræ of the spinal column are articulated by means of a cartilaginous substance. The vertebra itself consists of two peltate conical cups, and they are applied cup to cup, with their mouths in the articulation, the two adjoining cavities being filled with cartilaginous matter which unites them together, and allows of a very rapid and elastic motion without the least risk of dislocation. These vertebræ are generally furnished with very produced transverse processes which have the mesial plane, and to them the principal muscles are attached; the ribs are also in general articulated to lateral processes; but in many species the cavity of the body occupies only a very small part of the length of the animal.

Those bones of fishes, to which the ventral fins are attached, and which for this reason answer, at least in a slight degree, to the pelvis of mammalia, are not in any of the species articulated upon the spine; and in those which have them articulated on the throat, they are attached to the bones of the shoulders. The bones of the head vary much in different fishes; but the brain is in general not much developed. In the greater number the sense of vision seems to be acute, and the principal one upon which they depend. They also are, at least in some of the species, sensible to sounds, and have been trained to come at a call; but it does not appear that the sense of smelling and tasting are at all acute; nor does what we are accustomed to call the sense of touch seem to be very energetic. Pain and laceration, unless they affect the gills, or suspend in some way the more important functions of life, appear to be but little heeded by fishes. It is probable also that their locomotive powers are not so much injured by flesh wounds, even though serious ones, as those of the warm-blooded animals. Their muscles, though of a fibrous texture as they are in these latter, have their fibres differently arranged, they being interrupted at the surface of every two flakes of which the muscles are composed.

Fish are, as every body knows, generally covered with scales, varying much in form and character in different species. Except the mouth they have no prehensile organs by means of which they can lay hold of or retain those substances on which they feed, and though there are some that can adhere by suckers to rocks and other substances, there are none that can grasp.

Though very few fishes have the mouth adapted for biting or dividing their food, and none have a grinding motion of the jaws, yet they are very variously, and some of them very copiously furnished with teeth. As is also the case with birds and reptiles, the anterior parts of whose mouths, as in this class, are little else than prehensile instruments, which seize the food, but do little towards preparing it for the stomach, the fishes have a kind of double mouth. The anterior part above is formed of the intermaxillary and maxillary bones; and there are often bones even behind the arches of the gills, attached to the os hyoides or bone of the tongue; and all these parts, and also the tongue itself, are often beset with teeth; but to describe the functions and forms of all the varieties would require volumes. The os hyoides also supports the rays to which the gill cover is attached. This cover consists of three pieces, the operculum, the suboperculum, and the interoperculum; and in fishes which have the gills the most free, and, are, in consequence, the greatest breathers of the class, there is a preoperculum, with free motion, by which the apparatus of the gill-lid is articulated upon the tympanum. There are, however, very considerable structural differences in the breathing apparatus of fishes.

The digestive apparatus of fishes offers very considerable varieties, according to the nature of their food; but as we have not the same facilities of showing the different parts of their economy as we have in land animals, many of the conclusions to which the structure points, are, at the best, only vague and conjectural.

For the purpose of continuing the species, all the fishes, as indeed all the other vertebrated animals, have the sexes distinct in different individuals. The more characteristic ones, or those which are sometimes called the true fishes, are all oviparous. There is a sort of pairing, or, at all events attachment of the sexes for each other in this the most important part of their economy; but the impregnation of the ova, or roe of the true fishes, does not take place till it is excluded from the body of the female. Thus there is in them one step lower than there is in the batrachian reptiles; frogs, for instance, in which the ova are impregnated while in the act of exclusion. Viewed with that reverence which becomes rational beings when they turn their attention to the more important functions of the living creation, this is a most wonderful and most instructive matter. The care which is taken of the very rudimental germ of the animal, is in proportion to the development of the higher animal powers with which it is to be invested; and there are the most elaborate provisions made for the protection of the single embryo of most of the mammalia, while the most prolific of the fish which have their millions at a brood, cast that brood upon the waters, and leave it to the common course of nature.

There are, however, some fishes which are less perfect as fishes in other parts of their structure, which are viviparous, or, at all events, ovoviviparous, that is, which bring forward their impregnated germs internally; and either produce their young actually alive or in a horny envelope, by which they are protected from external injury. The shark and skate families have that habit; and though they are remarkable for their endurance, their energy, and in very many of the species, their voracity, it is worthy of notice that, in many structural parts, they are far less perfectly developed than most of the fishes which are purely oviparous, and commit their offspring to the waters.

Our knowledge of the anatomy of fishes is so imperfect, that there is more difficulty in forming such an arrangement of them as shall be useful as a means of knowledge, than there is in the case of any other vertebrated animals. There is, however, one great or primary division that applies to the structure, and also the principal habits and characters of fishes; and it has the advantage of our being able to form it on the skeleton, and not on mere external appearances. That is the division into bony fishes, or fishes properly so called, and cartilaginous fishes, or chondropterygii. The distinction between these goes further than that of the true fish, having hard bones, and the others a skeleton, more of the consistency of cartilage or gristle; for the chondropterygii, though they breathe air through the medium of water as well as the others, have the gills either attached to the walls of cells, or are without the perfect gill-cover, which characterises the true fishes.

COMMON FISH, OR FISH PROPERLY SO CALLED.

These form by far the most numerous of the two subclasses; but they admit of farther subdivision into two orders, *acanthopterygii*, or those which have spinous or unjointed rays in the dorsal fin, and sometimes the first dorsal, in the case of their having more than one, formed of spines only without any connecting membrane; and *malacopterygii*, which have the rays of the dorsal fin jointed or soft. The first of these great orders is by far the most numerous in species; but some of the most valuable, in an economical point of view, belong to the second. Our limits prevent us from giving any more than a mere list of the families, and in this we shall follow the arrangement of Cuvier, as the best approximation upon a subject where perfect accuracy cannot be obtained.

SPINOUS-FINNED FISH.

These consist of fifteen pretty well defined families, comprising many genera, species, and individuals, differing much from each other, but still agreeing in the general character on which the order is founded.

Percoides, the perch family. This family is named after the common perch, which, on that account, must be considered as the typical fish.

They are all very active fishes, of an oblong form, covered with large, hard, and rough scales, with generally strong spines in the dorsal fins, and the operculum, the preoperculum, or both, with toothed or with spinous edges. They have the jaws, the vomer, and generally the palatal bones, armed with teeth. Some, as the common perch, inhabit the fresh waters; but the greater number are found in the sea, and chiefly in warm climates. Their flesh is in general wholesome and palatable, but not so rich as that of many other fishes. They admit of subdivision, according to the part of the body on which the ventral fins are situated. The greater number have them thoracic, or immediately under the pectorals, and in their habits they are ascending and descending fishes; but they differ much from each other in their breathing apparatus, and in the form and number of their dorsal fins. They have the ventral fins attached to the same number of bones as the pectoral ones, so that the two act in concert. Another and much smaller division of this family have the ventral fins jugular, or situated on the throat in advance of the pectorals, and articulated on the os hyoides. This is the proper position of those fins in a bottom fish, because they really belong to and direct the motions of the head more than the body. Some of this division are very singular in their appearance, and equally singular in their habits. The weavers, which are found in muddy bottoms on various parts of the British shores, and inflict serious, but not, as is sometimes alleged, poison wounds, with the spines of their first dorsal fins, are instances; and a still more remarkable instance occurs in the star-gazer of the Mediterranean, which remains at the bottom in water of considerable depth, and is remarkable for the vast size of its eyes, which are placed so completely on the top of the head that it has no command except above the body. In it we can better see the mode in which those jugular fins act, the fish striking downwards with them, and thus darting the head upwards with great rapidity to seize any prey that may happen to pass over it. The mouth also opens upwards, and the whole structure is admirably fitted for enabling it to seize objects above it in the water. Fishes of this division, and, indeed, ground fishes generally, are far more tenacious of life than such as live and feed near the surface; and, excepting in their peculiar evolutions for the capture of their prey, their motions are slow and their range limited. Some of them which have been observed on the muddy shores of Northern Australia, have the action of the fins so powerful that they can leap about like frogs after the retiring tide has left the bank dry. A third division of this family has the ventral fins behind the pectorals, and generally so far behind that they are not in any way connected with the bones of the shoulder. This position indicates a more straight-forward motion; and that the body has to be raised as well as the head, and the fish to seek its food below it as well as above. The mullet, or perhaps rather the surmullet, which is so much esteemed by lovers of fish, and the mango fish of the Ganges, are specimens of this division. The last-mentioned one, which is reckoned the finest fish in Bengal, is remarkable for having the pectoral fins produced in thread-like filaments, some of which are double the length of the body.

2. *Armed Cheeks.*—Many of the fish of this family

are of singular appearance, on account of the hard plates, and often of the sharp spines with which the sides of their heads are furnished. Many of them also have long filaments on the sides of the head, in front of the abdominal fins. The gurnards are examples of this family.

3. *Scienoides.*—The maigre family have spines on the operculum, but no teeth on the vomer or palatal bones. Some of the species are common in the warmer seas, where their flesh is esteemed as food. On the British shores they are rare. The bones of the fore part of the head are generally hollow, which gives that part an enlarged appearance; and in many of the species the ventral fins are partially covered with scales.

4. *Sparoides*, the gilt-head, or sea bream family, are also fishes of the warmer seas, though individuals of some of the species occasionally stray to the British shores. The body is deep in proportion to its length, but compressed laterally; the dorsal fin is single, with spinous rays in the interior part, and soft ones in the posterior; there are two kinds of teeth, subject to great varieties in the different species; but in the more characteristic ones there are six incisive teeth in each jaw, and generally four rows of cheek teeth in the upper jaw, and three in the under.

5. *Menides.*—This is a small family chiefly confined to the warmer seas. They are distinguished by the upper jaw being retractile and protractile, in consequence of the long peduncles of the intermaxillary bones. Several species inhabit the Mediterranean; but the greater number are inhabitants of the tropical seas. One of the American species, the *stone-bass* of the West India

islands, is understood to stray occasionally to the coast of Cornwall. Many of the species are excellent as food.

6. *Squamipennes* (scaly fins), are distinguished by having the soft, and frequently also the spinous parts of their dorsal and anal fins so completely covered with scales that it is not easy to distinguish between the fin and the body. They are chiefly inhabitants of the warm seas, and equally remarkable for their singular shape and the beauty of their colours.

7. *Scomberoides.*—The mackarel family is composed of a vast number of fishes, having the scales very small and the body smooth. They are all remarkable for the power of the caudal fins, and the rapidity of their motion through the water. They are also highly valuable in an economical point of view, in which respect the common mackarel stands at the head of the family, especially in tropical climates. They vary greatly in form and appearance; and some are very singular. The tunny and the John Dory are instances. The sword-fish also is remarkable for the vast production of the snout or upper jaw, both sides of which are armed with formidable teeth, and altogether this single appendage is a very powerful weapon. Nor must we forget to mention the coryphine or dolphin of the ancients, which is celebrated in romantic story, and so splendid in reality, as one of the most brilliant inhabitants of the deep. In the tropical seas, and even in the Mediterranean, numerous shoals of those fishes drive along with the rapidity of lightning, and make the sea for miles as rich and radiant as if it were inlaid with all the gems of the east. On these occasions they are generally in

pursuit of the flying fishes, which leap out of the water only to fall into the jaws of the coryphine, just as the salmon in our estuaries leap out of the water in order to fall into the jaws of the seal or the porpoise. All the mackarel family, and indeed all surface fishes, are remarkable for their metallic lustre when alive, for the short time that they live after being taken out of the water, and for the rapidity with which the flesh becomes unwholesome. The luxurious Romans, who were perhaps the most thoroughly sensual people upon earth, used to bring the coryphine alive on the table before their guests, in order that these might glut their eyes with the changes of its colour while dying, before proceeding to gormandise on its flesh.

8. *Tænioides* (riband fishes).—The fishes of this family are remarkable for the length and slenderness of their bodies, which are compressed laterally, and sometimes the tail ends in a point, without any caudal fins. They chiefly inhabit the warm seas, but they are discursive, and a few are found on the British shores.

9. *Theutyes*, the lancet fish family.—These are very remarkable fishes, occurring chiefly in the warm seas, and some of them feeding exclusively upon sea weed. Their bodies have in many instances nearly the form of those of the flounders, but they stand the other way in the water, swimming on the thin edge, while the flounders, which are bottom fishes, swim on the flat one. Many of them are relished as food; but they are rather dangerous while living, because of the powerful spines with which certain parts of their bodies, often the tail, immediately in front of the caudal fin, are furnished. In the lancet fishes, pro-

perly so called, those spines are of considerable length, with edges as sharp as a knife, and when the sailors attempt to catch them they cut their hands to the bones. Those spines are, however, merely weapons of defence against their enemies, and not weapons of attack, if the fishes are let alone; and it is worthy of remark, that, as those vegetable-feeding fishes have their chief defences in the tail, so many of the vegetable-feeding mammalia have theirs in kicking with the hind feet, which is very remarkable in the horse, the kangaroo, and the giraffe, a blow of the foot of which last will shatter the skull of a lion to pieces.

10. *Pharyngii labyrinthiformi.* The fishes which belong to this family have a remarkable structure of the bones of the pharynx, that is, of the bones which, articulated to the os hyoides, are situated above the arches which support the gills. These bones are formed with a number of labyrinths, or cavities, capable of holding a supply of water, which the fishes can give out in small quantities, so as to keep the gills moist, and enable them to live when out of the water. This is a singular property, and most of the fishes which possess it inhabit singular countries, where they appear and disappear as if by a sort of miracle, in consequence of which the ancients supposed that they were rained down from the clouds. The fact is, that the supply of water in the cells of the pharynx enables the fishes to exist on dry land for a considerable time; and thus they climb the banks of the temporary pools, which become seasonally dry in tropical countries; and contrive to make their way over the land to the nearest

piece of water. The climbing perch of India is one of the most remarkable of the family, and it is sometimes found in trees a good many feet above the ground.

11. *Mugiloides*, the mullet family. The fishes of this family must not be confounded with those mullets or surmullets to which allusion has already been made. They get the name mugil from the murmuring sound produced by their gill-lids when taken out of the water and lying panting upon the shore. Their body is nearly cylindrical, their head depressed, and their muzzle short. Their bodies are covered with large scales, and their heads with scaly plates of an angular shape. The opening of their mouth rises with an angle in the middle, and a similar form of the bones of the pharynx gives the same angular appearance to the entrance to the gullet; and thus it admits only very minute substances to pass. The teeth are in general small, and in some of the species so very minute as hardly to be visible; but, contrary to what one would expect, the stomach is an organ of great power, being muscular, or having some resemblance to the gizzard in birds. At particular seasons of the year fish of this family resort to the mouths of rivers in large troops, and are remarkable for their activity, and the briskness with which they leap out of the water.

12. *Gobioides*, the goby or sea gudgeon family, are rather singular fishes. They have the spines of the dorsal fin slender and flexible, a large intestine without any cæcal appendages, and no air bladder. Some of them are small fishes, remarkable for the quantity of soft and glary matter with which their skins are covered; and of these the

greater number are ovoviviparous, or hatch their young internally, instead of depositing spawn as is the general habit of fishes. Many of them are very singular in their appearance, but most of them are comparatively small sized. Others are of more ample dimensions, among which may be enumerated the cat-fish or wolf-fish, which is remarkable for its powerful teeth and the ferocious cat-like appearance of its head. It is common on the British shores, and more so on the northern than the southern ones; its flesh is wholesome, but rather dry, and there is a prejudice against it in consequence of its appearance.

13. *Pectorales pediculati*, or fishes which have the pectoral fins with a pedicle or solid piece between the rays and the body, which gives to these fins something of the appearance and also of the efficiency of a sort of hand; from this we might infer that they are leaping fishes; and it is probable that those to which we formerly alluded as being found on the north coast of New Holland, and leaping about the banks like frogs, when the tide ebbs away, belong to this family, and not to the one under which we alluded to them. There are only two or three genera, which are not very handsome fishes, neither are they dignified with very choice names. One of them is called the sea-devil, from its hideous appearance; and another the sea-frog. They are chiefly mud fishes; and it is understood that the long filaments which are attached to their heads are used by them to entice those small fishes on which they live. The proper English name of the sea-devil is the angler. It is not uncommon on the British coasts; but its singular appearance makes it generally disliked.

14. *Labroides*, the labrus, so called from the size of their lips. They have an oblong body covered with broad, but rather thin scales. A single dorsal fin, supported in the interior part by spines, to each of which there is usually attached a membranous appendage. These fleshy lips are usually double, one immediately over the jaw, and the other beyond that. They have no cæcal appendages to the intestinal canal, and their air-bladder is usually of considerable size and strength. In some of them the teeth are pointed; but in others they are arranged on the jaw, like paving stones. The greater number of them inhabit the warm seas, and some the rivers of warm countries; but there are several species which are found on the British shores, though only on the south.

15. *Pipe-mouthed* fishes are remarkable for the prolongation of the fore part of the head into a sort of tube, at the extremity of which the mouth is situated. They are usually divided into *fistulariæ*, or pipe fishes, commonly so called; and *centrisci*, which have the body oval and compressed. The first have the body slender, and the tubular part of the mouth very much produced; and they are furnished with filaments issuing from between the lobes of the tail, which are sometimes longer than the body of the fish. They are very singular fishes in appearance, and found only in the warmer seas, with the exception of one small species, *centriscus*, which is not unfrequently met with in the Mediterranean. They are curious fishes, but, in an economical point of view, they are of little or no value.

MALACOPTERYGII.

These form the second great section of bony fishes; their general character is, that the rays of all their fins are soft and jointed, and do not, like those of the former, contain spines. There is in fact, a less disposition to the production of hard matter upon the surface of their bodies than there is on that of the former, and, taken altogether, their motion in the water is perhaps not so rapid; but some of these are exceedingly numerous, and to man they are the most valuable of all fishes. They are conveniently divided into three orders, according to the position of the abdominal fins, or the absence of these organs. Those orders are:—*abdominales*, or those which have the ventral fins situated behind the pectorals; *subrachiati*, or those which have the abdominal fins under, or in advance of, the pectorals; and *apodes*, or those which are without ventral fins. These distinctions do not relate merely to the structure of the animals, but are connected with some of their habits. Those with the abdominal fins are straightforward swimmers, and range chiefly in the free waters; those which have these fins situated far forward are more of ground fishes; and the apodal ones remain chiefly at the bottom of the waters.

MALACOPTERYGII ABDOMINALES.

These comprise by far the greater number of the soft-finned fishes, and they include very many of those which inhabit the fresh waters. They are subdivided into five families.

1. *Cyprinidæ*, the carp family, have the mouth with a small opening, and weak jaws, and, in most of the species, without any teeth. To compensate for this, however, the bones of the pharynx are very strongly toothed. The rays in the gills are not very numerous; their bodies are scaly; they have no soft fin on the back, and no cæcal appendages to the digestive organs. They are the least carnivorous of all fish, living mostly upon the roots and leaves of aquatic plants, and such seeds and other vegetable substances as fall into the water. The typical species is the common carp; and there are some which are very handsome in their appearance, and often kept in glass vessels as ornaments in rooms. The gold fish of China is one of the most remarkable of these ornamental fishes.

2. *Esoces*, or the pike family. These differ greatly in their disposition from the fishes of the former family, being as voracious and fond of animal food as the former are vegetable and harmless. There is no soft fin on the back; the upper jaw has its edge formed by the intermaxillary bones; the intestinal canal is short, and all are furnished with an air bladder. The pikes, properly so called, have the upper jaw furnished with small pointed teeth; and the vomer, the tongue, the palatal, and pharyngeal bones, and also the arches of the gills, thickly set with teeth arranged in the same manner as those of a card. The lower jaw is furnished with long and powerful teeth and they are remarkable for the strength of their bite. Some others of the family are of a more simple character, but remarkable for the production of their pectoral fins, which are so large as to support them for some time in the air. They are usually termed flying fishes,

but the epithet is misapplied, for they cannot fly—that is, they cannot give themselves either impulse or direction in the atmosphere. They merely spring from the surface of the water, and the great length of their pectorals enables them to rise to the height of a good many feet, and extend their leap to the distance of a good many yards. One can easily see, however, that they are helpless in the air, for each one rises in its own direction, and falls when the force of its leap is exhausted, without any of that consent which we find among winged animals which fly in concert. These are found only in the warm seas, to which they give a peculiar character, by rising out of the water as if they were birds, and sometimes alighting on the decks of ships. Sometimes, however, a straggler finds its way to the British shores.

3. *Siluridæ*, the silure family, differ considerably from the two families already mentioned, and also from the rest of the order. They in general have a naked skin without scales, though sometimes partially covered by plates of hard matter; the maxillary bones in the upper jaw are either rudimental, or they are produced into long and flexible barbels. They are furnished with a strong jointed ray as the first of the dorsal and pectoral fins; and they have sometimes soft fins on the posterior part of the back, as in the salmon family. The strong ray of the pectoral fin is often a very powerful weapon. One species of this family is the largest fresh-water fish which is found in Europe.

4. *Salmonides*, the salmon family, are among the most interesting divisions of the finny tribe. They have the body covered with scales; the first dorsal fin with soft rays, and the second small and

adipose, that is, consisting of a membrane filled with fat, and not supported by any rays. They are all furnished with an air-bladder, and most of them have numerous cæcal appendages to their intestines. Their motions are in general rapid through the free waters; and, generally speaking, they feed much and have rapid digestion. Some of them reside constantly in the fresh waters; and they almost all ascend the rivers and streams for the purpose of spawning. They are, perhaps, the most desirable, and the most wholesome and nutritious of fishes.

5. *Clupeæ*, the herring family. The greater number of these are salt-water fishes; but in many particulars they are closely allied to the salmon family. None of them, or at least few of them, inhabit the fresh waters, or ascend far up the rivers; but they all approach the shore for the purpose of spawning; and some of them do so in immense numbers, and are of great value in an economical point of view. The common herring is perhaps the most valuable, and the white bait the most esteemed by epicures as a dainty.

MALACOPTERYGII SUBRACHIATI.

These form the second grand division of soft finned fishes, and the third order of the whole class. They are divided into three families, all of which, however, have this general character, that the ventral fins are immediately under the pectorals, articulated upon and supported by the shoulder bones.

1. *Gadites*, the cod family. These are distinguished by having the ventral fins under the throat, and sharp and pointed. Their bodies are mode-

rately long, not much compressed, and covered with soft scales. Their heads are without scales; their vomer and jaws in the back part are armed with teeth generally of small size, and arranged like a card or rasp. Their gill openings are very wide, and their gills consist of seven rays. They are found chiefly in the temperate or cold seas, often in vast multitudes, and some of them are prolific absolutely beyond imagination, a single cod fish producing more than four millions of young at a birth. The cod, the haddock, the ling, and a number of others, belong to this family; they are known by the name white fish, from the colour of their flesh, and are perhaps more valuable than any other inhabitants of the waters.

2. *Flat-fish.* These have something very remarkable in their character. They are all ground fishes, found on the banks in the sea, or the estuaries of rivers; and, though they are flat as their name imports, and have one side generally white and the other coloured, the white side is not the belly and the coloured side the back, as in most fishes; but there is a twist in the neck which throws the eyes sometimes to the right hand and sometimes to the left; and the fish swims on the side, its principal motion being up and down, and not lateral, as in other fishes. The turbot, the sole, and the flounder are examples of these fish, which have their flesh white and very wholesome.

3. *Discoboli.* These have the ventral fins formed into a sort of disc, by means of which they can sometimes hold on upon rocks and other substances, and so catch their food in the water as it races past them.

MALACOPTERYGII APODES.

These form the fourth order of fishes, and the last of the soft-finned ones. They consist of only one family, *anguilliformes*, or eel-shaped fishes. Their general character is that of having no ventral fins, having the pectorals very much advanced, and swimming by the flexure of their lengthened bodies by a sort of wriggling motion resembling that of serpents. They are mostly ground fishes, and the common eel may be taken as a specimen.

Here, then, are two orders of fishes, not very numerous in genera or in species, but very peculiar in their habits, which do not fall in exactly either with the bony or the cartilaginous fishes.

Order V. *Lophobranchii.*— With the jaws complete and free, but with the gills arranged in tufts along the branchial arches. Their bodies are generally covered with hard plates; and they have a very singular appearance. There is scarcely any flesh upon their bodies; and therefore they are of little or no use. They are strange-looking creatures, and popularly known by the names of sea-needles, sea-horses, and others. They are found chiefly in the warmer seas.

Order VI. *Plectognathi*, soldered jaws.—These have the bones of the head united, and in this respect they approach the cartilaginous fishes, which have comparatively little distinction of bone and joint in that part of the body. There are two families of them, *gymnodontes* and *sclerodermi*. The first have no distinct teeth, but have the jaws covered with a plate of matter resembling ivory. They are strange-looking fishes, almost wholly inhabitants of the warm seas, and many have the body covered with spines, and are capable of inflating it like a ball. They are called moon fishes, and various other names.

The *Sclerodermi* have the body with a rough covering. Some of them are on that account called file fishes; but others have the body covered with large bony plates, and have it of such unusual figure that they are not improperly called trunk fishes. They, as well as the former family, are found chiefly in the tropical seas.

CHONDROPTERYGII.

These are the cartilaginous fishes which have all their bones flexible, and scarcely any distinction of bone and joint. These fishes have, however, many parts of their bodies more completely organised than the bony fishes; and in the matter of their reproduction, which is a very important one in the physiology of all animals, they approach more nearly to the higher orders of animals than even the more characteristic fishes. They are, generally speaking, ovoviviparous, and have connexion of the sexes, so that they form a sort of link between the true fishes and the other vertebrated animals. They are conveniently divided into two orders.

Order VII. (Of the whole class.) *Chondropterygii*, with free gills.—These have so far a resemblance to the ordinary fishes that their gills have a singular orifice, very open, but without any rays to the membrane. There are only two genera of them; the sturgeons, which generally inhabit the rivers of the colder countries, and are of large size and furnished with hard plates along their bodies. The flesh of the common sturgeon resembles veal, the air-bladder furnishes the finest isinglass, and the roe is prepared into caviare, which is highly esteemed in the Eastern parts of Europe. The other genus of this family is *chimæra*, which are very singular fishes, of extraordinary shape, and approaching slightly to the sharks in the structure of their breeding apparatus.

Order VIII. *Chondropterygii*, with fixed gills. —These have numerous gill openings, and some of them are the most rapacious of fishes. They include the sharks and skates, or rays, which constitute one family; and the cyclostomata, which constitute another. The sharks and rays have the mouth opening under the snout, and in some of the species it is armed with very formidable teeth. The cyclostomata have the mouth in the form of a sucker by means of which they attach themselves to the bodies of other fishes and exhaust their substance. The lamprey and the flag are examples of this order.

Such is a very imperfect outline of the finny tribes; but, brief and inperfect as it is, it is sufficient to show that the wisdom, the power, and the goodness of the Almighty are not confined to any part of His works; but that while the heavens and the earth declare His glory, the sea, in the mighty volume of its waters, witnesseth to the same, and the whole proclaim that He is "God over all, blessed for ever."

END OF VOL. I.

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