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A
SURVEY
OF THE
WISDOM OF GOD
IN THE
CREATION:

OR,
A COMPENDIUM
OF
Natural Philosophy.
IN FIVE VOLUMES.

By JOHN WESLEY, A. M.

A NEW EDITION, REVISED AND CORRECTED.

VOL. I.

These are thy glorious Works, Parent of Good,
Almighty! Thine this universal Frame,
Thus wond'rous fair! Thyself how wond'rous then!
MILTON.

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1809.

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WISDOM OF GOD
OF THE
SUNNY

IN THE
CREATION

A COMPANION

TO THE

IN FIVE VOLUMES

BY

NEW EDITION, REPRINTED AND CORRECTED

VOL. I

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PREFACE.

1. I HAVE long desired to see such a *Compendium of Natural Philosophy*, as was,
1. Not too diffuse, not expressed in many words, but comprised in so moderate a compass, as not to require any large expence, either of time or money. 2. 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, 3. In the plainest dress, simply and nakedly expressed, in the most clear, easy, and in-

VOL. I.

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telligible 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.

2. 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 any thing I have seen, is *Mr. Ray's Wisdom of God in the Creation*; *Dr. Derham's Physico and Astro-Theology*; *Niewentyt's Religious Philosopher*; *Mather's Christian Philosopher*, and *Nature delineated*. But none of these, single, 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.

3. 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 oc-

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

casion 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 will allow; although some of them, I know, will not be understood by an unlearned or inattentive reader.

4. Mean time I must apprize 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*.

5. 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 enquire, the more we are

March 25, 1775.

1. I HAD finished the additions which I designed to make to the System of Natural Philosophy, before I saw Dr. *Goldsmith's* "History of the Earth and Animated Nature." I had not read over the first volume of this, when I almost repented of having wrote any thing on the head. It seemed to me, that had he published this but a few years sooner, my design would have been quite superseded, since the subject had fallen into the hands of one who had both greater abilities and more leisure for the work. It cannot be denied that he is a fine writer. He was a person of strong judgment, of a lively imagination, and a master of language, both of the beauty and strength of the *English* tongue.

2. Yet I could not altogether approve of this, that it seemed the design of the au-

thor to say *all he could* upon every article, rather than *all he should* say. Hence arose his numerous and large digressions, making no inconsiderable part of his work. Hence his minute description of cows, horses, dogs ; of cocks, hens, and pigeons, and of abundance of animals equally known to every man, woman, and child ; descriptions that are of little or no use, and no more entertaining than useful ; at least useful only to the bookseller, by swelling the bulk, and consequently the price of his book.

3. Indeed this, the price of it, must ever remain a weighty objection to many readers : they cannot afford to purchase eight volumes at six or seven shillings a volume : ten or fifteen shillings they may possibly afford for five or six smaller volumes, especially when they contain all that is curious or useful in the far more

costly work. Nay, I hope, considerably more than all ; as I have consulted abundance of authors, and taken abundance of passages from them, whom I apprehend the Doctor had not seen.

4. I have another objection to this ingenious book; I doubt some parts of it are not true. The author, indeed, has corrected many vulgar errors, but has, I fear, adopted others in their place. Many times he exposes the credulity of other writers, but does he not sometimes fall under the same imputation? As where he terms *presumption*, to deny the existence of Bishop *Pontoppidan's Kraken*, and the *Sea-serpent*; the one a mile across, the other raising himself out of the water, higher than the main mast of a man of war! Could one who made the least scruple of rejecting these gross absurdities, accuse other writers of credulity?

5. Mean time, the accounts which he has given of many animals, being taken from the best and latest authorities, are both more accurate, and more to be depended on, than any which had been published before. Many of these I have inserted in their places, (only contracting thirty or forty pages into four or five) often in the room of those which were less accurate, and probably less authentic ; as also several of his beautiful remarks, such as directly tended to illustrate that great truth, *O Lord, how manifold are thy works ! In wisdom hast thou made them all !*

The first of these is the account which is
 given of the animals taken
 on the first and last expeditions
 to the mountains, and more to be
 added on the many which had been
 taken before. Many of these I have in-
 serted in this place (and extracting
 them from the pages in the text or vice
 versa) in the room of those which were less
 correct, and probably less authentic; as
 the first of the beautiful marks, such
 as the one added in the margin of the first
 page of the first expedition, are all
 in common with those which are

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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 philosophizing among the Hebrews and Egyptians.
3. — Among the Greeks.—The Philosophy of Pythagoras, Plato, and Aristotle.
4. The different Methods 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 Improvement made in every Branch of it: in Anatomy; the Discovery of the Circulation of the Blood; of the Lacteal Veins; and the Thoracic Duct.
9. Of the Generation of all Animals from Eggs.
10. Of the Transfusion of Blood.
11. Diseases themselves, and the Operations of Medicines, give occasion for farther Discoveries.
12. Many Anatomical Discoveries have been made by Microscopes.
13. Many with regard to Brutes, particularly Fishes and Insects.
14. Many likewise with regard to Plants, Stones, Metals, and Minerals.

15. Great Improvements from the Art of Chymistry.
16. Discoveries concerning the Loadstone.
17. Concerning Glass and Burning-Glasses.
18. The Nature of the Air is more accurately discovered by means of the Barometer, the Thermometer, and the Air-Pump.
19. Discoveries relating to Water.
20. Discoveries which shew the Nature of Fire, Gunpowder, Aurum Fulminans, Phosphorus.
21. Of the Earth, and the chief Systems of the Universe.
22. Of the Sun, the Planets, and their Satellites.
23. Of the Causes of Natural Bodies.
24. 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 ascend 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, philosophized 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 material causes of natural 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. *Aristo*

4. In succeeding times, when the four Greek sects, the Platonic, Peripatetic, Epicurean, and Stoic, divided the Western world between them, the Platonists almost confined themselves and their opinions to the subject of divinity ; the Peripatetics regarded little but logick ; the Stoics little but moral philosophy ; 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 School-men, 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 introduced the knowledge of chymistry into Europe, were wise above the age they lived in ; and penetrated so far into the secret recesses of nature, as scarce 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. And 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.

7. After this, not single persons only, but whole societies applied themselves carefully to make experi-

ments; 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 sciences at Paris, and those of the same kind in Germany, as well as several other parts of Europe.

8. To mention but a few of the late discoveries in each branch of natural philosophy, with regard to the structure of a human body, how many things have modern anatomists discovered, which were either little understood by the ancients, or wholly unknown to them? Such, for instance, is the circulation of the blood discovered by Dr. William Harvey, whose "Anatomic Exercitationes," concerning it, were first published in the year 1628. Such were the lacteal veins discovered first in brutes by Casper Asellius, of Cremona, and soon after in men. Such the thoracic duct, and receptacle of the chyle, observed first by Dr. John Pecquet, of Paris, whereby the whole course of the blood is now clearly understood.

9. Dr. Harvey improved natural philosophy by another no less eminent discovery: for he was the first of the moderns that shewed all animals to be generated from eggs. That the ancients knew and taught this, (Orpheus in particular) cannot reasonably be doubted. But as the knowledge of it was entirely lost, to revive was the same thing as to invent it. It is obvious how great a light this pours upon that dark subject with regard to the generation of men, as well as of other animals.

10. Another remarkable discovery in the last century was that of the transfusion of the blood. The blood of a young, lively, healthy animal, was transfused by means of a small silver tube, properly adjusted into the veins of another which was old, weak, and sickly, and the effect amazed all the beholders. When the experiment was tried before several of the royal society, a feeble worn-out dog, ready to die with age, and hardly able to trail his legs after him, was no sooner

filled with young blood, than he leaped up as from sleep, shook himself, and ran up and down as lively and active as a puppy. In France the experiment has been made upon men, and with as surprising success. What pity, that so important an experiment should ever fall into disuse; that it is not still repeated upon proper occasions; especially where all other means fail.

11. It cannot be denied that physicians have signally improved this branch of philosophy, as they have continual opportunities of making new discoveries in the human body. In diseases themselves, the wonderful wisdom of the Author of Nature appears; and by means of them many hidden recesses of the human frame are unexpectedly discovered. The powers of medicines also variously exerting themselves, lay open many secrets of nature.

12. And how many things in all bodies, as well as in the human, which eluded all the art and industry of the ancients, have the moderns discovered by the help of microscopes? Although these are not properly a modern invention, it being certain something of this kind was in use many hundred years ago. There are several works of great antiquity still extant; the beauties of which cannot even be discerned, much less could they have been wrought by the finest naked eye which ever was in the world. Such is that seal which was formerly in the cabinet of the late King of France, allowed to be at least 1500 years old, six-tenths of an inch long, and four broad, which to the naked eye presents only a confused groupe, but surveyed with a microscope, distinctly exhibits trees, a river, a boat, and sixteen or seventeen persons.

13. Now whatever assists us in searching out the structure of a human body, equally helps us to find out the nature and properties of other animals. Hence in these likewise we have received great light, from anatomical and microscopical observations. Those especially who have bestowed their whole time and thoughts on one kind of animal, (as Dr. Willoughby, on fishes,

Dr. Swammerdam, of Amsterdam, on insects) have illustrated to a surprising degree the subjects on which they wrote.

14. Many have diligently searched into the nature of plants; particularly Mr. Ray, who has not only ranged them in a new method, but also wrote an elaborate history of them. Others have described, with equal diligence, either plants in general or those of a particular country; and others have shewn the like industry in finding out and explaining the nature of stones, metals, minerals, and other fossils.

15. Nor is it strange that the moderns have penetrated farther into the recesses of nature than the ancients, considering the advantages they have received from the art of chymistry. Not that this is an invention of later ages: it was in some measure known long ago. But as this art has been cultivated in our age, with far greater accuracy than ever, so by this means many properties of natural bodies have been discovered, of fossils in particular.

16. But none of these have so much engaged the study of the learned, or so well deserved it, as the load-stone. Its attractive force was known to the ancients, and the origin of that discovery is recorded by Pliny. But it does not appear that they knew of its pointing to the pole, or of the use of the compass. This (the compass) was invented by John Goia, in the year 1300: but it has since been observed, that the magnetic needle seldom points exactly to the pole, but varies from it some degrees to the East or West in a fixed and regular order.

17. Nearly related to the nature of fossils is glass, which was well known to the ancients, being mentioned by Plutarch and Lucian among the Greeks, by Lucretius, Pliny, and others, among the Latins. Yet the art of making glass has been since their times abundantly improved. One branch of this is, the art of making burning-glasses, which are now brought to so great perfection, as either to melt or reduce to ashes the most solid bodies in a few moments. If these were

known to the ancients at all (which may reasonably be doubted) yet the art was wholly lost for many ages, and not recovered till of late years.

18. Later ages have likewise made many discoveries with regard to earth, water, fire, and air: the last of which, air, though it be of so fine a texture as to be wholly invisible, yet producing such amazing effects, has excited the most diligent enquiries of the curious. Nor does any part of philosophy afford a wider field for experiments and discoveries. The weight of it we can ascertain by that curious instrument the barometer, invented by Torricellius; the degrees of heat and cold by the thermometer. By the air-pump (invented by Otto Guerick, Mayor of Magdeburgh) the air is drawn out of any bodies, or more largely thrown into them, and hereby many effects are produced which deserve our diligent consideration.

19. With regard to water, the discoveries of later times are numerous and important. Such are the diving-bell, invented by George Sinclair; the diving-machine of Alphonso Borelli, a kind of boat which is so contrived as to be navigated under water: and the art of making salt-water fresh, which is now done with little expence, so far that the saltness is taken away, and it is fit for almost all uses.

20. The nature and properties of fire also have been accurately traced in late ages: for which new occasion was given by the invention of gunpowder, by Berthold Schwartz, in the fourteenth century. Aurum Fulminans, a yet later invention, goes off with a louder explosion than gunpowder. Other bodies there are, which do not burn, yet emit light; such is the Bononian stone, which placed in the dark, diffuses light like a burning coal. It is well known that the preparation called phosphorus has the same property.

21. Various theories of the earth have lately appeared, but they are no more than ingenious conjectures. The same may be said of the systems of the Universe, a few particulars excepted. The Ptolemaic system, which supposes the earth to be the centre of the Uni-

verse, is now deservedly exploded ; since Copernicus has revived that of Pythagoras, which was probably received by most of the ancients. Tycho Brahe's, which jumbles both together, is too complex and intricate, and contrary to that beautiful simplicity, conspicuous in all the works of nature.

22. The telescope (invented by Galileo) has discovered many stars unknown to the ancients, together with the nature and motion of the planets, both primary and secondary. By this also have been discovered the spots of the sun, the inequality of the surface of the moon, the nature of the galaxy or milky-way, and many other particulars relating to the heavens.

23. With regard to body in general, it is commonly supposed that our age has a vast advantage over antiquity, by having found out new principles and new hypotheses, whereby we can account for all the secrets of nature ; but this will bear a dispute. For beside that the chief of our hypotheses are not new, but known long ago, the learned have hitherto very little profited by all their hypotheses. And in truth, all their disquisitions touching the causes of natural bodies, terminate in mere conjectures : one whereof is often more probable than another, but none admits of any solid proof.

24. 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.

CHAP. I.

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OF MAN.

1. **A**S man ought to know himself best, we begin our treatise here. And first, let us contemplate the Human Body. The parts of this are either solid or fluid. Those of the solid, of which the rest are formed, are termed similar parts. Such are fibres, bones, membranes, ligaments, arteries, veins, lymphatic vessels, nerves, flesh, muscles, tendons : and those general coverings of the body, the cuticle, the skin, fat, and the panniculus carnosus.

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.

Earth, as an element, is a solid, opaque, angular, friable substance, of such small volatile particles, that

it readily diffuses itself through air and water, and resides invisibly in them. And earth eagerly imbibing both air and water, by their means forms the permanent basis and growth of all mineral, vegetable, and animal bodies.

These earthly particles have their connexion and power of cohesion, not from themselves or a mere contact; but from the intermediate glue placed betwixt them.

That this glue is composed of oil, combined with water, by the vital attrition in animals, appears from the chymical analysis of bones and hair; from the jelly of bones, ivory, and horns; and from the nature of our aliments themselves. Nor is there any kind of glue that could more powerfully join the parts of animals, as we experience in fish glue, and that of joiners or cabinet-makers.

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.

Of 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 with the neighbouring or contiguous fibres. Examples of such fibres we see in the bones, and most easily in those of a foetus; 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 microscopes of Muiyse and Lewenhoeck; 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.

From what has been said, we may admire nature no less for her wise œconomy than simplicity, in thus forming all that variety of parts we see in an animal, from one simple mass of clay 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, till 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 humours, with 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; viz. 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 parts of the body, conjoins them all together in such a manner as not only sustains, 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 to 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 iat into the cells; which are rather moistened by a watry vapour, somewhat oily, exhaled out of the arteries and received again into the veins.

Its plates or scales are still more loose and open where it divides 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 cavities 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 venal orifices. 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, the intervals or spaces betwixt the plates or scales that make up their sides in the cellular membrane, are every where 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 the 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, extremely sensible.

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, (beside 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 dilocated. 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 inclosed little bags. In these bags are glandulous bladders, serving both to discern 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, till 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.

The marrow not only serves to keep the substance of the bone moist, but to lubricate the joints, and to hinder the ends of the bone from being worn or over-heated with motion. It also moistens the Ligaments, which tie them to each other : as do likewise the glands found in all the joints. The backbone hath these two things peculiarly remarkable. 1. 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. 2. The difference of its own joints in the neck, back and loins. In the neck the two upper vetebrae are curiously made, and jointed (different 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 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, that it can neither be thrust backwards nor forwards to compress the medulla spinalis.

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

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 exceeding 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 spungy, as their extremities commonly are, nor hard and brittle; but capped with a strong, tough, smooth, cartilaginous substance, serving both for strength and motion.

For affording this oily matter there are glandules very commodiously placed near the joints, so as not to suffer too great compression by the motion of the neighbouring bones, and yet to receive a due pressure, to cause a sufficient emission of the oil into the joints. Another thing considerable is, that the excretory ducts of the mucilaginous glands have some length in

their passage from the glands to their mouths; which is a good contrivance, to prevent their mouths being oppressed by the mucilage, and also to hinder the too plentiful effusion thereof, but yet to afford a due expressure of it at all times, and on all occasions; particularly in violent and long-continued motions of the joints, when there is a greater than ordinary expence of it.

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 a short time, their bones are died red. When madder root was mixed with the food of a cock, who 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 tinged: in swine the teeth above all the rest.

5. Annexed to the bones are the cartilages, white, flexible, and smooth; most 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 inserted 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 the cartilage. The larger vessels, plunge in by numberless small holes, and disperse themselves into bran-

ches between the cartilage and bone. From these again there arise many short, but small twigs, which shoot toward the outward surface. This distribution of the blood-vessels is very peculiar, and calculated for obviating great inconveniencies. 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 one upon 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 cloathed with Membranes, which are whitish tunicks, 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.

The arteries ordinarily consist of three coats or membranes. The outermost has been generally thought to be composed of fine blood-vessels. The second is muscular, and made of firm and strong circular, or rather spiral fibres: of which there are more or fewer strata, as the artery is larger or smaller. These fibres are extremely elastic. The inmost coat is a fine dense, transparent membrane, containing the blood, which otherwise would easily ooze through the spiral fibre.

On a more accurate examination it has been found, that the outermost coat of all arteries is a cellular substance, composed of fine, pellucid membranes, which may be stretched, even suddenly to a great extent without breaking. And they as suddenly collapse, when that stretching force is removed. These cells contain an oily liquor which their coats seern from the branches of the artery that are spread over them. This cellular substance of the arteries serves to connect them with the surrounding part, without hindering their actions or motions. It gives a safe passage to the vessels of their other coats, and supplies oil for lubricating them. There is also another cellular substance, between the membranes and the muscular coat.

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 till they inosculate with the veins, and so form one uninterrupted channel.

They appear white, because their coats are of so dense a contexture, that the blood is not visible through them. This proceeding from wider to narrower canals is continually obstructed in its passage, but being pushed on from behind, it distends the coats, and causes that leaping motion called the pulse. By this, as well as by their whiteness, 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 eighty in that time; and again, by the night's rest or sleep, it will become less frequent, till in the morning you will find it return to sixty-five. For the voluntary motions of the muscles, and actions of the external and internal senses, urge the venal 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 humours 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 Fahrenheit'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 hotter, 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 degrees 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. i.e. 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.

8. A vein is a hollow canal, which receives the blood from the artery, and conveys it back to the heart. The chief veins are three, the vena cava, which pours the blood through a wide passage into the right ventricle of the heart; the pulmonary vein, which in like manner pours it into the left ventricle; and the vena portæ, which does not, like the two former, end in a large trunk, but spreads itself at each extremity into numerous branches.

In the cavity of the veins there are certain thin tunics, which are termed valves. These, during the regular motion of the blood, lie close to the side of the inner coat; but in case of any obstruction, recede from it and close the passage, to prevent the blood's falling back.

9. The lymphatic vessels are small canals full of valves, consisting of a thin transparent tunic, which convey an extremely clear liquid into the mass of blood. Probably these (as well as the veins) and all the other vessels, are only continuations of the arteries.

It has been lately discovered that the lymphatic vessels have two coats, betwixt which there are innumerable fine filaments containing a nutritious juice, which is conveyed into all parts of the body by a motion from the centre to the circumference, and returns through the inner pipes of the same watry vessels; but this juice, when returning, is no more water or dew, but ferment, and the vessels may be termed ferment-vessels. This ferment is conveyed into the blood by a motion from the circumference to the centre.

The lymphatics carry their dewy particles through the glandules, which lie between the two coats. In the lowermost end of these glandules, the ferment vessels take their rise. Most of the juice of the lymphatic vessels is discharged between the coats of the veins, arteries, and vessels, in the mesentery, to be conveyed into all parts of the body, both internal and external. Even in bearing females, the fruit is not nourished by blood, but by this nutritious juice; the remaining part of which is transmitted into the blood through the thoracic duct and jugular veins.

10. A nerve is a whitish, round, slender body, arising from the brain, which is supposed to convey the animal spirits to all parts of the body. What these spirits are none can shew; nay, we are not sure they have any being. For none can certainly tell whether the nerves are hollow canals or only solid threads enclosed in proper integuments.

11. The fibrous, soft, reddish part of the body is termed flesh. All fleshy fibres are hollow, and divided through their whole length into little caverns, wherein the blood is detained, as occasion requires.

12. A gland is a soft and spongy body, which separates some particular liquid from the blood. The larger glands contain arteries, veins, and lymphatic vessels; but the glands of the intestines are only the tops of the arteries.

There is a kind of down in the cavity of every gland, which probably does the office of a filter, and is that whereby a particular humour is separated from the blood.

The structure of the down-vessel is different according to the different purposes of nature. Sometimes the liquor filtrated through it, falls drop by drop on a membrane, to which one end of the vessel is fastened, as where it is designed only to moisten the part. Sometimes many of these down-vessels spread over the inner

surface of a membranous cell, into which they all pour their liquor, which is discharged at a small orifice.

These vessels are often of a great length, though they take up little room, being wound over one another, sometimes in a single knot and sometimes in several, enclosed in a common membrane. And hence is the distinction of glands into conglobate and conglomerate.

A conglobate gland is a little smooth body, wrapt up in a fine double skin, with only an artery and nerve passing in, and a vein and excretory duct going out.

A conglomerate gland is an irregular assemblage of several simple glands, which are tied together and wrapt under one common membrane.

13. A muscle is a bundle of fibres joined and fastened together, with their proper veins, arteries, and nerves. It is divided into little cells by transverse fibres, parallel to each one, whereby it may be contracted and shortened, or relaxed and lengthened again. Its extreme parts are more closely compacted, which we term tendons; by these the muscles are connected with the neighbouring parts. A muscle generally consists of three parts; the upper, termed the head, the middle, termed the belly, and the lower part or tail.

Every muscle is divisible into smaller muscles, and those into other still smaller, and so on beyond all imagination. The last and smallest parts are muscular fibres, but there is no assignable point in any muscle wherein there is not some nerve, and here all the nerves disappear; (in other parts their extremities expand into membranes.) It is therefore probable that the muscular fibres are only the nervous continued.

14. The cuticle or scarf-skin, is an extremely thin and transparent membrane, void of sense, and covering the skin all over, sticking fast to its surface, to

which it is also tied by the vessels that feed it; it consists of several layers of exceeding small scales, which cover one another where it is thick, but in the lips, where it is extremely thin, they little more than touch one another.

In some creatures (as fishes) these scales are only the excretory ducts of the glands of the skin; in others, those glands have their proper ducts, opening between the scales.

It is supposed there are in one scale 500 excretory ducts, and that a grain of sand will cover 250 scales. If so, a grain of sand will cover 125,000 of our pores.

The cuticle serves to defend the nerves of the skin, both from the air, which would dry and make them less sensible, and from rough and hard bodies, which would make a painful impression on the naked nerves.

Negroes have a skin between the cuticle and the true skin. They are born white, but the middle skin, in a little time, turns black, and gives that colour to the whole body.

But who can account for the following case? Sir C. Wager had a boy about eleven years old, who was born in Virginia, of negro parents: till he was three years old he was like other black children; he then, without any distemper, began to have little white specks upon his neck and breast; these increased with his years, both in number and bigness, so that from the upper part of his neck, quite down to his knees, he was dappled with white spots, some of them broader than the palm of a man's hand. They were wonderfully white, equal to the skin of the fairest lady, only somewhat paler. His face, arms, and legs, were perfectly black; he was exceeding active, sprightly, and more ingenious than is common among that generation.

Perhaps the following fact is no less difficult to be accounted for. A negro woman, cook to Colonel Barnes, in Maryland, about forty years of age, remarkably healthy, had her skin as dark as that of the

most swarthy African; but that part of it next her finger nails, about fifteen years ago, became white. Her mouth soon underwent the same change, which has since gradually extended over the whole body. At present, four parts in five of her skin are white, smooth, and transparent, as in a fair European, elegantly shewing the ramifications of the subjacent blood vessels. The other parts daily lose their blackness, and partake of the prevailing colour. The neck and back retain most of their pristine hue; the head, face, breast, legs, and arms, are all white. Her face and breast, when anger or shame has been excited in her, have been immediately observed to glow with blushes. This is the naked fact; but upon what principles of philosophy can we account for it?

The skin covers almost all the whole body, and is formed of whitish fibres, intermixed with numberless branches of nerves, veins, and arteries. On its surface are many furrows or indented lines, having generally hairs on each side, and pores or little holes of various sizes, serving for the transpiration of superfluous particles. 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 enls 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 so 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, scarce 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 subtilty, equability, and plenty of what we perspire, are the grand symptoms of health.

But how little do we know even of our own frame! It has hitherto passed as an unquestionable truth, that the same matter which passes by insensible perspiration, passing in great quantities, is sweat. Whereas an ingenious physician, Dr. Rogers, has found by numerous experiments, that a person perspires abundantly less, when he sweats, than when he does not; that one who perspires twenty four-ounces in seven hours sleep,

if he sweats, does not perspire above six. This he tried many times, and never found it to fail. Whence he infers, 1. That it is not the same matter which is evacuated by insensible perspiration and by sweat; 2. That it is not evacuated through the same pores: 3. That the sweat-pores are abundantly larger and fewer, than those which serve insensible perspiration: 4. That sweat greatly hinders that perspiration, both by covering those pores with a clammy liquor, and by constringing them so that they cannot open, which must be the case, when the sweat pores are dilated. What a field does this open!

Some queries proposed concerning perspiration, by an ingenious writer, seem to deserve a serious consideration. 1. "Why do carnivorous animals sweat so little? A fox hunted almost to death never sweats. 2. Why do those which feed on vegetables perspire so much? Horses and cows for example. We may often see them involved in a cloud of their own vapours, yea, almost covered with froth. 3. How can animals, whose natural food is vegetables, be kept alive, and in health, in very cold climates, by purely animal food? Cows in Iceland and Norway are fed in winter upon fish-bones." I would beg leave to ask 4. Do the sweat-pores only imbibe? Or those also, which serve for insensible perspiration?

15. Fat, a whitish oily substance, void of sense, is secreted from the blood, and lodged in small oval, membranous bags, which shoot out of the arterics. 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 scerned 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.

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.

16. The fourth general integument is the panniculus carnosus, which in some parts is of a fleshy substance; in others, a mere membrane, lying just under the fat.

17. The dissimilar parts are composed of the similar. The chief of these is the head. The cavity of the skull 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 divided into two plates, one laid over the other. Between these is a spongy 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 flattened 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.

18. All these are involved in 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.

19. 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, enclose the inner part, ordinarily to the thickness of about half an inch.

It consists, therefore, of innumerable little glands,

contiguous to each other, (supposed to secern the animal spirits) 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.

20. 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 farther progress they are distinguished by coats, detached from the two membranes of the brain, into several bundles called nerves, resembling so many horse-tails, each wrapt up in a double tunic.

Several of these part from the rest in the brain itself, of which there are ten pair; one on each side. From the spinal marrow there arise thirty pair more. All these, while within the skull or the spine, are pulposus; but afterwards harden, acquire a coat, and spread through the smallest points of the solid parts of the body. Their coats are every where 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.

21. 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 enclosed 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.—Is it such a reservoir of blood for extraordinary occasions, as some imagine the spleen to be?

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. Nay, there are many instances of insects living a long time, after their head is cut off. Hence it appears, that the spinal marrow alone may, for a season, suffice both for life, sensation, and motion.

Are there distinct provisions 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 every where 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 scirrhusities of this part have been sustained without any fatality to the patient, may be affirmed by certain experience.

22. The eyes next offer themselves to our observation, guarded by the eye-lids, eye-lashes, and eye-brows. The eye-lids consist of the cuticle, the skin, a thin expansion of the panniculus carnosus, and an inward coat. A palisade 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 eye-lids being bent upward, and those of the lower, downward. Mean time the eye-brows hinder sweat, or any thing else which might be hurtful, from falling down from the forehead.

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

23. 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 eye-lid, keep the eye-ball moist, to facilitate its motion. By these glands, tears also are secreted. The eye is connected with the surrounding bones by the tunica adnata, commonly call 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.

24. 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 the *uvæa*. It is much thinner than the former, though thicker than the *pia mater* from which it proceeds. In the forepart of it is a round hole, which with the chrystalline 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 late 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 kinds of fish. Finally, anatomy demonstrates that the choroides is seated in the blind part of the eye, but is itself of a white colour.”

25. The Aqueous humour, resembling the colour and consistence of 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 humour runs 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 chrySTALLINE, 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 forepart 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 toward 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 chrySTALLINE 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, 2000 of which have been counted in one chrySTALLINE. 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 forepart is concave, as receiving the chrySTALLINE ; the other side is convex.

The whole apparatus of the eye tends to this, that there be produced in the bottom of it, a distinct collection of all the rays, which proceeding from any

point of an object, penetrate the chrystalline 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 chrystalline. Mean time 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 chrystalline, 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 chrystalline 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 chrystalline 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 it appears; 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 double. In either eye 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 objects, 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.

Some odd circumstances relative to the eyes, are related by a physician in the Philosophical Transactions.

“ A person had no visible disease in his eyes, yet could not see, unless he squeezed his nose with his fingers, or saddled it with narrow spectacles, and then he saw very well.

“ A maid, 23 years old, could see very well, but no colour besides white or black. She could sometimes in the greatest darkness, see to read almost a quarter of an hour.

“ A sadler’s daughter had an imposthume, which broke in the corner of her eyes, and out of it there came about thirty stones, as big as small pearls.

“ A young man in Suffolk, about twenty years of age, has all the day a clear and strong sight. But when twilight comes, he is quite blind, nor can he see any thing at all, either by fire-light or candle-light. No glasses give him any help. He has been thus, ever since he can remember. This cloudiness comes gradually upon him, like a mist, as day-light declines. It is just the same, both in summer and winter, and at all times of the moon.

“ When I was about sixty my sight was so decayed, that I could not distinguish men from women. I

received no help from any glasses, till I took spectacles with the largest circles. Close to the upper semicircle on both sides, I cut the bone, and taking out the glasses, put black Spanish leather, taper-wise into the emptied circles. These took in my whole eye at the wider end, and through the narrower end I can read the smallest print. Into this end I can only put my little finger, not quite to the first joint. But they may be made wider or narrower, and longer or shorter, as best fits every eye.

“ At first I could not bear them above two hours at a time : now I can use them above twelve hours in four and twenty. And they prove a great help to those who are purblind, who have weak eyes or decayed with age. But for the purblind they must be made shorter, longer for eyes decayed with age.

“ Instead of leather, they may be made of paper, coloured black, and pasted on, and with inner folds to be drawn out, from one inch to three.”

In some men the iris has a faculty of darting out light. Dr. Willis mentions one, who after drinking wine plentifully, could see to read in the darkest night. And Pliny records of Tiberius Cesar, that if he waked in the night, he could see every thing for awhile, as in the broad day-light. Dr. Briggs gives a parallel instance of a gentleman in Bedfordshire.

We find various substitutes for the use of the eyes, in many blind persons. In some the defect has been supplied, by an excellent gift of remembering what they had seen ; in some by a delicate sense of smelling ; in others, by a fine sense of hearing. So Richard Clutterbuck of Redborough in Gloucestershire, who was stone blind, had so curious an ear, that he could hear the fine sand of an hour glass fall. In some it has been supplied by an exquisite sense of feeling, so that the same Richard Clutterbuck was able to perform all sorts of curious works. He could not only take a watch in pieces, and set it together again, but could also make all sorts of stringed instruments of music. He likewise played on them by notes cut in their

usual form, and set upon protuberant lines on the wood. Yet even this hardly came up to the skill of Van-Eyck, the organist of Utrecht, who, though he had been blind from two years old, played on all sorts of instruments.

Others have been able to take a face by the touch, and mould it in wax with the utmost exactness: as was the blind sculptor, who thus took the likeness of the Duke de Bracciano, and made a marble statue of King Charles the first extremely well.

26. But more than all this, some persons have been able even to distinguish colours by the touch. Peter of Maestricht, though perfectly blind, distinguished by his touch the different colours of cloth. John Vermaasen of Utrecht did the same; judging by the different degrees of roughness which he felt.

Yet blind persons, even though they distinguish them by the touch, have no idea of visible objects. Thus the gentleman couched by Dr. Chesselden: 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 was 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 stedfastly and said, "Sopuss, 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 afterwards 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 shewn 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 any thing into a pint. But even blindness, he observed, had this advantage, that he could go any where 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."

27. I would beg leave to propose a few queries here to which I have not found a satisfactory answer.

1. Why do we see things false with one eye? Particularly with regard to their situation.

2. How do the two eyes compound the rays of light, so as to see right?

3. Why do we not see all things double?

4. Since all things are painted upside down on the bottom of the eye, why do we not see them so?

28. We now 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 the 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 hear, 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 all animals, where the meatus auditorius is long enough to afford harbour to ear wigs, or other insects, ear-wax is constantly to be 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 the ears so well guarded, and so little tunnelled.

29. In this, 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 stiled 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 neve.

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 œconomy 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. Thus a physician at Amsterdam taught several children born deaf, to understand what was said and to give pertinent answers.

Mr. Goddy's daughter of Geneva lost her hearing at two years old. Yet by observing the lips of others, she had acquired many words, whereby she would talk whole days with those that could understand her. But she knew nothing of what was said, unless she saw the mouth of the speaker: so that if they wanted to speak to her in the night they were obliged to light a candle. Only she knew what her sister said even in the dark, by laying her hand on her mouth.

But many deaf persons can hear, if a loud noise be made while you speak. Dr. Willis mentions one, who, if a drum was beat in the room, could hear very clearly. So that her husband hired a drummer for his servant, and by that means conversed with her daily.

30. The nostrils are made not 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 odorous particles are drawn in, the laminae 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 laminae is divided into

many others, folded into a spiral line. The *os cibrosus* 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 exudication, 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 a man, but prolonged to the very end.

31. The tongue has for its basis that forked bone, called the *os gutturis*. 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 makes 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.

It has been generally supposed, that the tongue is essentially necessary to the formation of speech. But as sure as we have been of this, it is an entire mistake. A child in Essex, some years ago, had her tongue entirely cut out, by reason of an incurable canker. She was then three years old. Twenty years after, it was reported, that she was able to speak. To be satisfied hereof, Mr. Benjamin Boddington, Turkey merchant of Ipswich, with two other gen-

tlemen, went to Wickham Market, where the young woman then lived, whose case they thus describe :

“ We have this day been at Wickham Market, to satisfy ourselves concerning Margaret Cutting. We examined her mouth with the greatest exactness, but found no part of the tongue remaining ; nor was there any uvula. The passage down the throat is a circular open hole, large enough to admit a small nutmeg.

“ Notwithstanding this she swallowed both solids and fluids as well as we could do, and in the same manner. Yea, and she talked as fluently as other persons do. She pronounced letters and syllables very articulately, even those which seem necessarily to require the help of the tongue, as d, l, t, w. She read to us in a book distinctly ; she sings very prettily ; nay, and she distinguishes tastes, and can tell the least difference either in taste or smell.”

But is it possible to teach any one to speak, who has been deaf and dumb from his birth ?—

It is. Dr. Wallis taught such an one to speak. Mr. Daniel Whaley of Northampton. He was present before the Royal Society, May 21, 1662, and did there pronounce, distinctly enough, such words as the company proposed to him : indeed not altogether with the usual tone, yet so as easily to be understood. In a year, which was the time he staid with Dr. Wallis, he read over great part of the English bible, and learned to express himself intelligibly in common affairs, to understand letters written to him, and to answer them. And in the presence of many foreigners, he has not only read English and Latin to them, but has pronounced the most difficult words in their languages, which they could propose to him.

The doctor has since done the same for Mr. Alexander Popham, a gentleman of a fair estate.

But we have an instance of dumbness cured in a

shorter time. Henry Axford, son of Henry Axford, in the Devizes, at twenty-eight years of age, perceived a hoarseness, and in about six days became quite speechless; not only unable to speak articulately, but to utter the least sound with his tongue. His cold went off, but he remained absolutely speechless; and the advice of all the neighbouring physicians did not help him.

He continued totally dumb for four years, till in July, 1741, being at Stoke, in returning homeward at night, he fell from his horse, and was taken up and put to bed in a house upon the road. He soon fell asleep, and dreamed, he was fallen into a vessel of boiling wort. Struggling with all his might to call for help, he actually did call aloud, and recovered the use of his tongue from that moment, as perfectly as ever he had it in his life.

Perhaps, therefore, there is truth in that ancient story, concerning the son of king Cræsus: namely, having been dumb from his birth, he had never spoke at all, till in the battle, seeing a man ready to kill his father, his tongue was loosed, and he cried out aloud, "Soldier, spare the king!"

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 molting or casting their feathers. The seed 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.

That part of the tooth which stands out of the gum, is covered with a peculiar substance called enamel. It is composed of an infinity of little tubes, which grow on the bone by their root. 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 providently 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 jaw-bone, 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 chissels, 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 holdfasts 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 work.

32. The Palate is of a bony substance, a little concave, and clothed with a thick membrane, which has the same kind of nervous 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.

It would be endless to specify the curious mechanism of all the parts that concur to form the voice. However, let us note two things : 1. There are thirteen muscles provided for moving the five cartilages of the wind-pipe. 2. It is amazing that the glottis, (the upper part of the wind-pipe) can so exquisitely contract or dilate itself, to form all notes. "Suppose (says Dr. Keil) the greatest distance of the two sides of the glottis to be one tenth of an inch, in sounding twelve notes (to which the voice easily reaches) this line must be divided into twelve parts, each of which gives the aperture requisite for such a note. But if we consider the subdivision of notes into which the voice can run, the motion of the sides of the glottis is still vastly nicer : for if of two chords, sounding exactly unisons, one be shortened but the two thousandth part of its length, a just ear will perceive the disagreement, and a good voice will sound the difference : and yet this is only the one hundredth and ninety-sixth part of a note. But suppose the voice can divide only into a hundred parts, it follows, that the different apertures of the glottis, actually divide the tenth part of an inch, into twelve hundred parts, the effect of each of which produces a sensible alteration upon a good ear."

33. The Uvula is a round, oblong, fleshy substance, suspended near the passage from the mouth into the nostrils, and probably designed to hinder the cold air, from rushing too fast into the lungs, as well as to prevent the food we swallow from regurgitating into the nostrils.

The Tonsils, or almonds of the ear, are two small

glands, placed at the root of the tongue, which supply an humour, to keep the mouth and the tongue continually moist.

The Wind pipe 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 wind-pipe 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, they are, some completely round, some triangular. Another thing observable is, in the wind-pipe, 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.

34. The Hairs are all hollow. The root of each hair is fixed in a mucous globule, of an oval figure, which often adheres to it, when it is pulled up by the root. They are jointed like a reed or cane, and shoot out into small branches. They serve not only for a covering, but also for the excretion and expiration of an oily matter.

Every hair does properly live, and receive nourishment like the other parts. The roots do not turn white or grey in age, any sooner than the extremes. But the whole of each hair changes colour at once. Or (to speak more properly) the hairs of another colour fall off, and white ones grow in their place.

But extreme fear may turn the hair grey, or even

white in a short space. So it was in that famous instance some years ago. A nobleman in Germany, was condemned to die, and ordered for execution in the morning. During the night, in ten or twelve hours time, all his hair turned white as flax. The emperor being informed of this, said, "he has suffered enough:" and pardoned him.

Since that time, there has been an instance of one of our own countrymen, who being shipwrecked, saved himself on a small rock, surrounded by the sea. A boat took him off after he had stayed there four hours. But in that space his hair was turned quite white.

Perhaps a still stranger instance of this kind is related in the duke of Sully's memoirs. "Henry IV. told the marquis de la Force, that the moment he was informed Henry III. had published an edict, (in July, 1585) ordering all the Hugonots either to go to mass, or to abandon the kingdom in six months, his mustaches turned suddenly white on that side of his face, which he supported with his hand."

Its life is a peculiar kind, and approaches to the nature of vegetation. Hairs grow much as plants grow out of the earth, or as some plants grow upon others: from which they draw their nourishment, and yet each has its life distinct from the other. So hair derives its food from some juices in the body; but not from the nutritious juices. Accordingly the hair may live and grow, while the body is starved to death.

That hair may grow merely as an excrescence of the vegetable kind, appears from that memorable case recited by Mr. Hook, of a body which, having been buried forty-three years, was found in a manner wholly converted into hair. The woman was buried in a coffin of wood, and lay the lowest of three in the same grave. The others, being removed, and this coffin appearing, it was observed that much hair came through the clefts of it: on removing the lid, the whole appeared a very surprizing sight. There was

the whole figure of the corpse, exhibiting the eyes, mouth, ears, and every part. But from the very crown of the head, even to the sole of the foot, it was covered over with a very thick set hair; long, and much curled. The people, amazed at this appearance, went to touch the corpse. But the shape fell away, as it was handled, leaving only a quantity of shapeless hair; but neither flesh nor bones, only a small part of the great toe of the right foot.

Each hair consists of several smaller ones, wrapt up in one common covering. They send out branches at the joints. The root lies pretty deep in the skin: and by this they imbibe their proper nourishment, from the adjacent humours. Their extremes also split into two or three branches, especially if they are very dry, or too long. So that what appears a single hair to the naked eye, to the microscope appears a brush. They are grey on the forepart of the head first, particularly about the temples: the back part affords them nourishment longer. For the same reason they fall from the crown of the head first. Their thickness depends on the size of the pores they issue from: if these are small, the hair is fine. If the pores be strait, the hairs are strait; if oblique or sinuous, the hairs are curled.

All hairs appear round. But the microscope discovers some of them to be square, others triangular; which diversity of figures arise merely from the diversity of the pores. Their length depends on the quantity of humours proper to feed them, and their colour on the quality. And hence the colour usually differs in the different stages of life.

The hair of a mouse is a transparent tube, with a pith of small fibres convolved, running in some hairs spirally, in some transversely, in others from top to bottom.

The Nails are of the nature and fabric of the cuticle, like which they are also insensible, and renewable, after being cut or fallen 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.

35. 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 is inserted in 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 that 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 ventricles into the veins, and from the arteries into the ventricles. In a healthy person, the heart contracts little less than five thousand times in an hour.

36. 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 constricted 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.

The brain has an alternate contraction and dilation, answering those of the heart. It is highly probable, the weight of the atmosphere is the counterpoise to the contractile force of the heart. That of the brain, being not near so strong, does not need so strong a counterpoise.

In the basis of the heart, in some animals, there is a bone frequently found. Such an one was found in the heart of Pope Urban. Probably it was only the tendons of the heart ossified.

Wounds of the heart are not always so immediately mortal as is generally supposed. A soldier was brought into one of the hospitals in Paris, with a wound in the upper part of the left breast. He seemed very well for three days: but on the fourth was taken with a fever and difficulty of breathing, and died on the tenth. On opening the body, it was found the sword had pierced the pericardium, traversed the right ventricle of the heart in its lower part, pierced the pericardium on the opposite side, and gone through the diaphragm, and an inch deep into the liver.

37. The heart is placed in the middle of 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 wind-pipe. 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 bronchia. 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 upper end of the trachea is called the larynx. At the fourth vertebra of the back, it divides and enters the lungs. Its cartilages, ranged at small and equal distances, are smaller and smaller as they approach the lungs.

These cartilages have two membranes. The external, composed of circular fibres, covers the whole trachea. That which lines it within, consists of three distinct membranes, the first woven of two orders of fibres, part longitudinal, to shorten it by drawing the cartilages together : part circular, to contract them. Both these, together with the external membrane, assist in breathing, coughing, and varying the tone of voice. The second membrane is glandulous ; and its glands opening into the cavity of the trachea, separate a liquor which moistens and defends it from the acrimony of the air. The third is a net-work of nerves, veins, and arteries.

The organs which form the voice of man, have not been accurately observed by the ancients. As the trachea bears some resemblance to a flute, they considered the voice, according to the sounds of that in-

strument. Mr. Dodart was the first who shewed the glottis to be the chief organ in producing it, and considered it both as a string and wind instrument, far more perfect than any which art can produce.

The organs which form the various voices of other animals, are likewise worthy of our attention. Those of each species have peculiar sounds, whereby they understand each other.—Wherein do these organs resemble ours? and wherein do they differ?

The human voice is almost wholly formed by the glottis, and various tunes are produced by the various modifications of it. But all these depend on one only; the separation and junction of its lips. This comprehends two circumstances, the one capital and primitive, the other, a consequence of it. The first is, That the lips are more and more bent, from the lowest to the highest note. The second, That the more they bend, the nearer they draw to each other. It follows from the first, that their vibrations will be more frequent, as they come nearer the highest tone, and that the voice will be exact when they are equally bent, and the reverse when unequally: which corresponds perfectly well with the nature of stringed instruments. It follows from the second, that the higher the tone, the nearer they draw to each other. And this agrees perfectly with those wind-instruments which are governed by reeds. From these simple, and almost imperceptible variations, proceeds the infinite variety of sounds.

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 also a tendinous membrane, which concurs in forming the voice. Others have several membranes: others a kind of bags, which in some are 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 jirks. 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 on 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 shew, 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 mem.

branous bags; situated on each side, above the lips of the glottis. What is remarkable is, that each lid 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 a quadruped's, 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 quinsies. This physicians were at first encouraged to do, from the case of a Cornish gentleman, who had his wind-pipe quite cut through, and yet was cured and lived several years after.

38. In order to the admission and expulsion of the air by the lungs, it is necessary the breast should be contracted and dilated. This end is served by the bony part of the Thorax, the intercostal muscles, and the diaphragm, a broad, muscular part, reaching across the breast, and dividing the middle from the lower cavity. It runs obliquely from the sternon and ribs before to the vertebræ of the loins behind.

39. 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 lengthways into two parts.

40. 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 sternon, or breast-bone, is an admirable guard to the noblest parts. To the same end serve the shoulder-blades and the back-bone, as well as to support the whole fabric.

The breasts consist 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 breasts, by means of which the tubes are constricted, and the motion of the milk is modified.

In virgins, the glands of the breasts are so contracted, that no blood can enter them. But when the womb swells with the fœtus, and compresses the descending trunk of the great artery, the blood forces its way into them. They admit thicker and thicker serum, till after the birth, they run with a thick milk.

It is more difficult to account for the milk, which some men have in considerable plenty. Thus in the year 1684, a countryman, called Billardino di Billo, living in a village near Nocæra, in Umbria, when his wife was dead, took the child, and put the nipples of his breasts into its mouth, invited it to suck, which the infant did, and after several times drawing, fetched some milk. After awhile it brought down the milk so plentifully, as to nourish it for many months till it was weaned.

Almost as strange is the following account: One informing me of an old woman that gave suck, I went to the house in Tottenham-court-road. Her name is Elizabeth Bryan. She is in the 68th year of her age, and has not borne a child for many years: her face is withered, her cheeks and mouth sunk in: but her breasts are full, fair, and void of wrinkles. About four years ago, her daughter was obliged to leave an infant she gave suck to, in the care of her mother. The old woman finding the child froward for want of the breast, applied it to her own. Having done this several times, her son thought the child seemed to swallow, and begged his mother he might try, if she had not milk. It soon appeared she had, and she then continued to suckle the child in earnest. Two years after, her daughter had another child, on which the grandmother weaned the first, and suckled the second. Both the children are healthy, plump, and firm in flesh, and as brisk and lively as can be desired."

41. In the lower cavity first occurs the Stomach, with the oesophagus 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, till 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 muscle 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 cavity of a healthy stomach, from whence they never escape but by a morbid affection.

The fabric of the stomach answers to that of the oesophagus, 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 oesophagus, 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 easy 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, from whence it is derived. Immediately within this, lies (6) the villous or velvet-like coat, that lines the cavity of the stomach itself, contiguous 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.

42. 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 ileum, is termed the small-guts; the lower part, divided into the cœcum, 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, watry 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 no where 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 umbilical region, and is usually twelve or thirteen hands long. The ileum, situate below the navel, fills the ilia with its numerous convolutions. It is much the longest of 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 cœcum, is literally 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 cœcum of a dog has been cut out, without any perceivable prejudice.

The colon is the largest of the great guts. It runs into various circumvolutions from the cœcum 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.

43. The Lacteal Veins, 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.

44. The Intestines are covered with the omentum or cawl, which is contained within the peritoneum, a very thin, soft, double membrane, and wholly consists 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 flatulencies; 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 spittle, helping to dissolve the food.

45. Under the diaphragm on the right side, lies the Liver, whence it extends over the right part of the stomach, below the sternum, toward the left, growing gradually smaller, that it may not hinder the distention 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 retails 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 choledocus, and then into the duodenum.

The principal use of the bile is to 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.

46. The Spleen is an elegant net-work of number-

less 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. Others imagine it to be a kind of reservoir, wherein on extraordinary occasions, that blood may be received, which would otherwise oppress the viscera and disturb the animal functions.

47. 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 habit. 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 vessel which goes round the neck of the bladder.

48. We proceed to the limbs. The hand (physically speaking) is divided into the arm, the cubit, and the hand, properly so called. In this there are twelve bones, besides fifteen in the fingers, all oblong, slender, hollow, and so fitly joined together by ligaments, so wonderfully provided with various muscles, adapted to so many different motions, that the hand alone gives us an abundant argument of the admirable wisdom of God.

Is there any possibility that the want of so necessary an instrument as the arm should be supplied? One would think it impossible. But it is not: such is the amazing power of God! James Walker was born in

1718, in Ireland, in the parish of Hillsborough. His mother could not be delivered till the surgeon totally separated the arms of the child from the body. Nevertheless he lived, and in the room of his arms, had little protuberances that appeared as stumps. He grew to be six feet high, slender, and active. "He sits a saddle, says an eye-witness, upright and firm, will ride 40 miles a day to a fair, and deals in buying and selling horses, which he dresses and curries as well as any groom can do, holding the curry-comb between his chin and shoulders. The same way he holds the goad in driving the plow, and the spade when he digs. He throws a stone from the top of his foot with greater force than most men can with their hand, and seldom fails to hit his mark. He mounts a horse without any assistance, and shuffling the bridle over his head, till he gets it on his shoulders, guiding his horse with as little fear, and as much skill as any man."

49. The Thigh consists of one bone, the largest and longest in the whole body. It is a little crooked, bending forward before, that there may be more room for the muscles. The bones of the leg are two, distant from each other in the middle, but joined together at each end. They are nearly of the same length, but the inner is much thicker than the outer. The bones of the foot are twelve, beside fourteen in the toes; which like those in the hands, are most aptly connected by ligaments, and fitted with muscles of various kinds, serving for equally various motions.

50. Thus far we have spoken concerning the solid parts of the body. Among the fluid are usually reckoned the animal spirits, supposed to be secreted in the brain, to flow through the nerves, and to be the instruments of sense and motion.

"But are the nerves in general hollow canals, which contain a circulating fluid? Or are they solid threads, which being highly elastic, vibrate variously

to occasion various sensations?" The latter supposition is wholly overthrown by the phenomena of wounded nerves. A nerve cut asunder, does not retract its divided extremities, but becomes rather longer, extruding its medulla into a round tubercle. Again, were it elastic, it should be composed of hard fibres, having their extremities fixed to some firm bodies: since strings, otherwise constituted and disposed, have no elasticity. But it is evident all nerves are soft at their origin, as well as void of tension, and some soft in every part, as the olfactory nerve, and the soft portion of the auditory nerve. Yea, they all grow soft in the viscera, the muscles, and the sensories, before they exert their functions. Besides, some nerves are so situate, that they cannot vibrate, as those of the heart, which are fastened to the great vessels and the pericardium. Further, the influence of an irritated nerve is never propagated upwards; whereas an elastic chord communicates its tremors to both ends from the point of percussion. Hence it is plain the nerves do not act by their spring, but by the motion of their proper fluid. The extreme smallness of these canals, which no microscope can reach, is no valid objection to this, neither our inability to discern that fluid. This only proves the imperfection of our senses.

"But what is this fluid?" Who can tell? We may very probably conjecture, it consists of some subtle fire or ether, diffused through the whole system of nature, and acting by laws unknown to us.

51. Of the other fluids, some serve to prepare the chyle, some to thin the blood and preserve it from putrefaction. Others only remain till they can be thrown out of the body, as being useless and superfluous. All of these, but the chyle, arise from the blood, being secreted from it by proper glands. But as to the manner of secretion, after all the most accurate and laborious enquiries, it still remains absolutely uncertain, and every one abounds in his own

sense. Some believe it depends on the suitableness of the fluid secerned, to the shape of the discerning pores. Some lay the stress rather on the various size and diameters of those pores: others on this, that the constituent particles, suppose of the bile, from their peculiar proportion, texture, and figure, may be more easily united to each other, than to the particles of lymph, or any other fluid.

52. The chief of all the fluids in our body, and the fountain of life, is the Blood. It consists of a watry serum, fibrous particles, and red globules, which last are scarce a twelfth part of it. It is generated thus. The meat and drink being digested into chyle, pass from the intestines, through the lacteal veins 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 homogenous. 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.

A red globule is computed to be 25,000 times smaller than the smallest grain of sand.

But whence arises the heat of the blood? This deserves a particular enquiry.

Fermentation is that spontaneous, intestine motion, which by the heat of subterraneous caverns, will in a few hours so change vegetable juices, (for fermentation is confined to the vegetable kingdom) as from a vapid wort quenching fire, to nourish fire, and to afford that inflammable liquor, commonly called spirits.

Effervescence arises from an intestine motion excited in various fluids, by the mixture of other fluids, or of salts or powders of a different nature. Acids

and alcalis, when mixed, cause a great ebullition, but no great heat; whereas the solution of some metals in aqua-fortis, causes intense heat, and emits flame. Aromatic oils, mixed with acid mineral spirits, kindle and burn with violent explosions.

In these cases, as there is no adventitious fire, there must be fire lying hid in one or other of the bodies. And it is known, much air lies dormant in all bodies. It is known likewise, that fire cannot exert itself without the help of air. It being granted then, that fire and air lie dormant in all bodies, there is only required such an action as may set at liberty the particles of air and of fire. By this action the particles of air recover their elasticity, and putting those of fire in motion, cause heat, but not incension, unless this fire meet a proper pabulum, which pabulum is sulphur only, though differently modified, whether in the appearance of brimstone, oil, spirits, metalline sulphur, or the most inflammable of all, animal sulphur, commonly called phosphorus.

In fermentation, the fire and air being let loose, produce warmth, but seldom kindle, because of the water predominating. But in the effervescence, produced by the solution of metalline sulphur, they kindle and sometimes cause explosions. Aromatic oils, containing little but the sulphureous parts of the vegetables, immediately kindle and break out into flame. And phosphorus is so highly inflammable, that if it be only exposed to the air a few minutes, it kindles and flames.

Now all animals contain more or less phosphorus. Some insects constantly shine in the open air. Many sorts of fish are luminous: some quadrupeds emit light, on a very slight friction. These are proofs of phosphorus lying dormant in animal fluids: and as they all contain air likewise, let only the phosphoreal and aerial particles be brought into contact, and heat necessarily ensues.

This clearly explains the cause of animal heat: of which the heart and arteries are the occasion; not by friction, but by the intestine motion, which the cir-

culation gives to the several particles that constitute the mass of animal fluids. As the velocity of these fluids is increased, the particles of which they consist come oftener into contact, and the oftener the phosphoreal and aerial meet, the more heat they produce.

But to what cause is the colour of the blood owing?—

Borelli took some of the red part, and washing it frequently in water, found it separable into a viscous slippery substance, consisting of colourless fibres which rose and gathered into a scum on the top of the water, and a deep red powder, which precipitated plentifully to the bottom. Hence it appears that the redness of the blood springs from red tinging particles, as in the case of dying.

However, this red colour, though generally found in the blood of land-animals, is not absolutely necessary, there being some species, whose blood is white or limpid. Nay, Dr. Drake let out of the median vein of a man, a pure, white blood, like milk, which when cold, did not separate into two parts, as the red usually does. Nor yet did it yield any skim or cream, neither turn sour as milk uses to do. Dr. Beal gives an instance of the same kind; and Dr. Lower relates one as strange. A person bled at the nose, till at length the broth he drank flowed out very little altered.

It is amazing to see, how careful providence has been, to prevent the blood's running into concretions, which might destroy life, by the very dispositions of the vessels it is to run through. These are so contrived, so as to cause the globules to come together with a brisk collision. The arteries which convey the blood from the heart to the extremities, continually lessen as they recede from their source; in consequence of which the globules of blood must rush with force against one another, as they are driven on impetuously. And the veins which bring it back from the extremities to the heart, enlarging all the way as they go on, while the streams of several continually run into one, each of these ingresses causes

new commotions, capable, though not of dissolving that natural connexion of the red and serous particles, yet of preventing any preternatural concretions or coagulations.

53. These are the parts of which this wonderful machine is composed, which the chymists say, consists of four sorts of matter, earth, water, salt, and sulphur, the particles of which being variously mixed constitute larger particles of different kinds; out of which, more loosely or closely connected, all the parts of the body, so id or fluid are composed.

But this is far from being an accurate account. For what are salt and sulphur but species of earth? May not we then much more properly say, with the ancients, that the body is chiefly composed of earth and water, yet cannot enjoy even animal life, unless air and fire, also be wrought into its frame? So that at whatsoever time, it is deprived either of air or fire, it is an useless, lifeless clod. And yet the manner how these are so intimately mixed, both with our fluid and solid parts, as much exceeds our comprehension, as the manner how the soul is united to its house of clay.

That much air is wrought into the whole animal frame, appears by the following experiments. The blood of a sheep, fresh drawn, was in a wide-mouthed glass put into a receiver, and the air drawn out. After awhile, the subtile parts of the blood forced their way through the clammy ones, and seemed to boil in large clusters, some as big as nutmegs; and sometimes the expansion was so vehement, that it boiled over the glass.—— Some milk being put into a vessel four or five inches high, when the air was drawn out, it boiled so impetuously, as to throw up several parts out of the glass that contained it.

And to shew that not only the blood, but the other parts of animals include air; the liver of an eel was put into a receiver, and even this apparently swelled every way, as soon as the air was withdrawn.

The air as a fixed element in the composition of

solid and fluid bodies, has been generally overlooked by philosophers, and even by the chymists, who have above all sects, gloried in their knowledge of principles, or elements; until Mr. Boyle, Sir Isaac Newton, and more especially Dr. Hales, by many experiments demonstrated that a great part of the substance of most bodies, in several to half their weight, is a permanent or unelastic air, which being freed [either (1) slowly, by the air-pump, putrefaction, fermentation, distillation, &c. or (2) suddenly by explosions, fulminations, ebullitions, mixtures, &c.] from the other solid particles, assumes its elasticity, and fills an immense space, in comparison of the body from whence it came. Dr. Hales found a cubic inch of blood, in distillation, afforded above 30 times its bulk of elastic air; whose particles are in effect the wedges of nature, which pin and cement together the other elements, and particles of bodies for their growth of accretion, and under other circumstances, regaining their elasticity, serve to break again those parts for the dissolution of the compound, whose matter may be, by the same instrument, again differently assembled and combined for the forming of other bodies.

54. 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 upward, 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, 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 incon-

veniences! 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 awhile. 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 a 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 pyramids 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 pyramids were built, 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, than 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 a sepulchre, and the other the cover.

This tomb was of free-stone ; 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 a 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 tex-

ture ; 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 the head was very 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 chesnut 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 hands smelt 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

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 œconomist 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 chymistry: 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 as 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,

destined 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 encumbrances. 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 hindmost, 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 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

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 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 are only 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 tore 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.

On this remarkable subject, I beg leave to add an extract from a late author :

“ I always apprehended that human bodies after death, if interred, or exposed to the air without any preparation to defend them from the attacks of it, would of necessity corrupt, become offensive, and putrify. The art of embalming is very ancient, and was invented to preserve them from this inevitable consequence of death ; but that they may remain unputrified for centuries without any sort of artificial aid, I have seen so incontestibly proved since my arrival at Bremen, that I imagine not the shadow of doubt can remain about it. Under the cathedral church is a vaulted apartment, supported on pillars ; it is near sixty paces long, and half as many broad. The light and air are constantly admitted into it by three windows, though it is several feet beneath the level of the ground. Here are five large oak coffers, rather than collins, each containing a corpse. I examined them severally for two hours. The most curious and perfect, is that of a woman. Tradition says, she was an English countess, who dying here at Bremen, ordered

her body to be placed in this vault uninterred, in the apprehension that her relations would cause it to be brought over to her native country. They say it has lain here two hundred and fifty years. Though the muscular skin is totally dried in every part, yet so little are the features of the face sunk or changed, that nothing is more certain than that she was young, and even beautiful. It is a small countenance, round in its contour : the cartilage of the nose and the nostrils, have undergone no alteration : her teeth are all firm in the sockets, but the lips are drawn away from over them. The cheeks are shrunk in, but yet less than I ever remember to have seen in embalmed bodies. The hair of her head is at this time more than eighteen inches long, very thick, and so fast, that I heaved the corpse out of the coffer by it : the colour is a light brown, and I cut off a small lock, which is as fresh and glossy as that of a living person. That this lady was of high rank seems evident from the extreme fineness of the linen which covers her body. The landlord of the inn, who was with me, said, he remembered it for forty years past ; during which time there is not the least perceptible alteration in it. — In another coffer is the body of a workman, who is said to have tumbled off the church, and was killed by the fall. His features evince this most forcibly. Extreme agony is marked in them : his mouth is wide open, and his eyelids the same ; the eyes are dried up. His breast is unnaturally distended, and his whole frame betrays a violent death.—A little child who died in the small pox is still more remarkable. The marks of the pustules, which have broken the skin on his hands and head, are very discernible ; though one should suppose that a body which died of such a distemper, must contain in a high degree the seeds of putrefaction.—The two other corpses are not less extraordinary. There are in this vault likewise turkeys, hawks, weasels, and other animals, which have been hung up here, some time immemorial, some very lately, and are in the most complete preservation:

the skin, bills, and feathers are all unaltered. The magistrates do not permit that any fresh bodies be brought here. The cause of these phenomenons are doubtless the dryness of the place where they are laid. It is in vain to seek for any other."

A repository of nearly the same kind, a late writer informs us is at a monastery, near Palermo, in Sicily. It is a long, subterranean gallery, having niches on every side, between six and seven feet high. In each of these is a human body standing erect, in its usual apparel. The face and the hands are uncovered, and preserve their shape, and natural colour, only a little browner. They are fastened to the wall by the back. Some of them are believed to have been there two or three hundred years.—Suppose they could remain there for ever, what would it profit their former inhabitants!

Another traveller gives a fuller account of them.

"This morning we went to see a celebrated convent of Capuchins, about a mile without the city of Palermo; it contains nothing very remarkable, but the burial-place, which indeed is a great curiosity. This is a vast subterraneous apartment, divided into large commodious galleries, the walls on each side of which are hollowed into a variety of niches, as if intended for a great collection of statues: these niches, instead of statues, are all filled with dead bodies, set upright upon their legs, and fixed by the back to the inside of a nich. Their number is about three hundred; they are all dressed in the clothes they usually wore, and form a most respectable and venerable assembly. The skin and muscles, by a certain preparation, become as dry and hard as a piece of stock-fish; and although many of them have been here upwards of two hundred and fifty years, yet none are reduced to skeletons; though the muscles in some are more shrunk than in others; probably because

these persons had been more extenuated at the time of their death.

“Here the people of Palermopay daily visits to their deceased friends, and recal with pleasure and regret the scenes of the past life : here they familiarize themselves with their future state, and choose the company they would wish to keep in the other world. It is a common thing to make choice of their nich, and to try if their body fits it, that no alterations may be necessary after they are dead ; and sometimes by way of voluntary penance, they stand for hours in these niches.

“The bodies of the princes and first nobility are lodged in handsome chests or trunks, some of them richly adorned : these are not in the shape of coffins, but all of one width, and about a foot and a half, or two feet deep. The keys are kept by the nearest relations of the family, who sometimes come and drop a tear over their departed friends.

“These visits must prove admirable lessons of humility ; and they are not such objects of horror as one would imagine : they are said, even for ages after death, to retain a strong likeness of what they were when alive : so that, as soon as you have conquered the first feelings excited by these venerable figures, you only consider this as a vast gallery of original portraits, drawn after the life, by the justest and most unprejudiced hand. It must be owned, that the colours are rather faded ; and the pencil does not appear to have been the most flattering in the world : but no matter ; it is the pencil of truth, and not of a mercenary, who only wants to please.

“It might also be made of very considerable use to society : these dumb orators could give the most pathetic lectures upon pride and vanity. Whenever a fellow began to strut, or to affect the haughty, supercilious air, he should be sent to converse with his friends in the gallery : and if their arguments did not bring him to a proper way of thinking, I would give him up as incorrigible.”

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 a system 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 larger 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 the 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 strait 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 master-piece 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 productions 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 of 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 are we 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 incumber 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 the 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 tunics, to enwrap 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

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 needs require.

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 strait 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 wind-pipe : 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, 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 any thing vici'd, 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 nature, 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 worm-like motion protrude it and force its small particles into the lacteal vessels. These are a series of the finest strainers, ranged into countless multitudes all along the sides of the winding passage. Had this been strait 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 nutritious 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 mixt 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 upward 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 allwise 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 to 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, enclosed within coats, it shews us all the graces and glories of nature. How wonderful, that an image of the hugest mountains, and the widest 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 subtle varia-

tions. These living chords, turned by an Almighty hand, and spread through the echoing isles, 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 shew 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 enquire 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 past 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 exigences 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 motions. The Will in some cases has no power : in others she is an absolute sovereign. If she commands, 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 vertebræ of the neck with all their appendant chambers ; we advance the leg with the whole encumbent 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.

CHAP. II.

Of the Natural State of the Human Body.

1. What the natural State of the	9. Of Smelling.
Body means.	10. Of Tasting.
2. Of the Circulation of the	11. Of Feeling.
Blood.	12. Of Hunger and Thirst.
3. Of Respiration.	13. Of Sleep.
4. Of Chylification.	14. Of local Motion.
5. Of Nutrition.	15. Of voluntary and involuntary
6. Of the Senses.	ry Motions.
7. Of Sight.	16. Of the Stature of Man.
8. Of Hearing.	17. Of the Age of Man.
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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, respiration, chylification, nutrition, and motion.

2. That the blood circulates through the whole body appears hence. Any of the arteries being tied with a thread will swell and beat between the bandage and the heart, but grow flaccid between the bandage and the extremities of the body. And if the artery be cut between the bandage and the heart, blood streams out even to death; but if it be cut between the bandage and extremities very little blood comes out. The vital blood, therefore, flows from the heart, through the arteries, toward the extremes of the body, and still out of a wider part into a narrower, out of the trunk into the branches.

Any of the larger veins being tied with a thread, swells between the extremes and the bandage, but grows flaccid between the bandage and the heart; if opened in the former part it bleeds largely, if in the latter scarce at all. The blood therefore flows from all the extremes through the veins into the heart, and still from the smaller parts of the vein to the larger, from the branches to the trunk.

Upon the whole, it is evident that all the arteries are continually bringing the blood from the left ventricle of the heart, through the trunks of the arteries into their branches, and from thence to all parts of the body: and on the contrary, that all the veins (except the vena portæ) are continually bringing it back from all parts of the body, through the small branches into the larger, and thence through the trunks and vena cava into the right ventricle of the heart; so that the whole blood passes through the heart once in five or six minutes.

It is certain that all the arteries and veins communicate or open one into the other, because often from one, and that a small artery, all the blood shall run even unto death, not only out of the wounded limb, but from the whole body. Of such fatal examples we have a number; from an inward artery of the nose, from the gums, a finger, a tooth, a cutaneous pore enlarged, from the lachrymal point, from the wound of cupping on the skin, and even the bite of a leach. There are, therefore, of course, open ways by which the blood speedily flows from the venal into the arterial system, and the reverse.

Late writers have pursued the globules of blood to a great length, and found several orders of them. The large ones visible to the naked eye are globules of the first order. Each of these is composed of six smaller, joined together in a very regular way, but sometimes a red globule is seen loosening and breaking into these compounding spherules, and sometimes one may perceive these running together and beginning the composition of a new red globule. These smaller spherules

they call globules of the second order. But we are not to stop here. There are in the blood a great many particles six times less than these. Globules of the second order are compounded of these smaller ones, which therefore are globules of the third order.

Farther. There are innumerable blood vessels of such smallness, that none of the abovementioned globules can pass them; so that we cannot but suppose still smaller globules. The diameter of some vessels is less than the eighth part of the diameter of a red globule, so that the particles passing through them must be above five hundred times less than those globules. Nay, on a careful examination, we perceive vessels narrower than the tenth part of the diameter of a red globule, which consequently can transmit spherules no greater than the thousandth part of a red globule.

On the whole then, each globule of the first order is made up of six of the second; these of six of the third, those of six of the fourth, these of six of the fifth, and so on. And accordingly we find the globules of the highest orders may be broken down into their compounding particles.

The diameter of a common red globule is about the 1938th part of an inch. The diameter of a globule of the tenth order is less than the 400,000th part of an inch.

Anatomists and physicians have generally determined the quantity of blood in the human body to be between fifteen and twenty-five pounds; but Dr. Keil shews from many instances of profuse hæmorrhages, that a far greater quantity must be allowed, otherwise the patient could never have furnished, or at least survived such evacuations, the least of which exceeded the whole quantity of blood supposed to be in the body.

In reality the quantity of blood in a human body is difficult to be determined. Bleeding to death, the usual method, can never shew what is its true quantity; because no animal can bleed longer than while the great artery is full, which will require a longer or a shorter time as the wounded artery is smaller or

greater; and the great artery must always be the first vessel that empties.

The only certain way of calculating is, to find what proportion the cavities of the vessels, of which the whole body is composed, bear to the thickness of the coats. This in the veins and arteries may be exactly found; but in the other vessels we only know the quantity of fluid they contain by carefully evaporating as much as possible. Thus the Doctor found the fluids to be in the arteries as 17 to 1; in the veins as 15,6 to 1; in the bones as 1 to 1. The least of these proportions shews the liquors to be one half of the weight of the body; and if a calculation be made on the proportion of the blood in the arteries, also to their coats in a body weighing 160 pounds, there will be found 100 pounds of blood or circulating fluid.

In a *fœtus* the circulation is performed in a peculiar manner. The septum, which separates the two ventricles of the heart is pierced through with an aperture called the foramen ovale, and the pulmonary artery, a little after it has left the heart, sends out a tube into the descending aorta, called the communicating canal. When the *fœtus* is born, the foramen ovale closes, and that canal dries up into a simple ligament.

The *fœtus* while in the womb receives little air. Its lungs, therefore, cannot swell and subside, they continue almost at rest; nor can they allow the blood to circulate either in abundance or with ease. Nature, therefore, has excused them from the passage of the greatest part of the blood, and has contrived the foramen ovale, by which part of the blood of the vena cava passes through the right ventricle into the left, and by this means it is found as far on its journey as if it had passed the lungs: but this is not all, for that blood of the cava which, missing the foramen ovale, passes from the right auricle into the right ventricle, being still too much to pass by the lungs, the communicant canal intercepts part of it, and pours it immediately into the descending aorta.

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. In the latter it is contracted, the diaphragm rising and the ribs falling again. Whenever the cavity of the breast is enlarged, the air by its weight naturally presses into it, and mixing with the blood in the vesicle of the lungs, makes it more fluid, globular, and fit for motion. Air is likewise absolutely necessary in the body, to counteract the pressure of the outward air.

But if the blood in the lungs of a foetus has not the advantage of respiration, it receives a portion of air, transmitted with its mother's blood by the umbilical vessels, to be diffused through the body. This is quite necessary, as appears hence; tie the navel string very tight, and the child dies like a man strangled.

One use of respiration is, to push the blood from the right to the left ventricle of the heart: hence it is, that persons strangled so suddenly die, because with respiration the circulation of the blood ceases. And this is the true cause of the diastole of the heart; the weight of the incumbent atmosphere being the true antagonist to all the muscles that serve both for inspiration and the contraction of the heart. As in the elevation of the ribs a passage is opened for the blood into the lungs, so in the depression thereof, by the subsiding of the lungs and compression of the blood-vessels thereby, the blood is driven through the pulmonary vein into the left ventricle of the heart. And this, together with the general compression of the body, by the weight of the atmosphere, is that power which causes the blood to mount in the veins, when the force impressed on it by the heart is nearly spent, and which forces the heart itself from its natural state of contraction to that of dilatation.

When in an ordinary expiration, the pressure on the larynx is two ounces, the pressure on the whole

internal substance of the lungs is 14412 pounds. So vast is the extent of the surface of the vesicles, on which it was necessary the blood should be spread in the finest capillary vessels, that each globule of blood might, as it were, immediately receive the whole force of the air, and thereby be broken into smaller parts, fit for secretion and circulation.

And hence we see the reason for the structure of the lungs. For since all the blood is to pass through them, in order to receive the effect of the air, and that this could not be done unless it were diffused in very small vessels; it was necessary the surface on which they were to be spread should be proportioned to their number, and this is admirably well provided for by the fabric of the lungs.

If the diameter of the trachea at the time of every expiration were the same in all, and the weight of the air always equal, the pressure on the lungs would be always the same. But as the difference between its least and greatest gravity is no less than a tenth part of the whole, that pressure is likewise greater by a tenth part at some times than it is at others.

This is a difference which the asthmatic must sensibly feel, especially as they breathe thicker, that is, every expiration is performed in less time. In truth, these feel a difference in the air, upon the greatest rise and fall of the barometer, equal to above one third of its pressure in ordinary breathing.

The alternate dilatation and contraction of the thorax are so necessary to animal life, that there is no animal without this or something analogous to it. Fishes and insects have no dilatable thorax; but fishes have gills which receive and expel the water alternately, whereby the blood-vessels suffer the same alterations of dimension as those in our lungs do; and insects have air-vessels distributed through the whole trunk of their bodies. By these they communicate with the external air through several vent-holes, to which are fastened so many wind-pipes which send branches to all parts, and seem to accompany the blood-vessels all over the

body, as they do in our lungs only. And hereby in every inspiration the whole body is dilated, and in every expiration compressed.

But may it not be doubted whether the primary end of respiration be not to supply the whole animal machine with the ethereal fire, a particle of which is connected with every particle of air? Is not this detached from it by the action of the lungs, and thence communicated to every part of the body? And is not this the true vital flame, the original source of life and motion.

4. Chylification is preceded by digestion, which is much illustrated by Mr. Papin's Digester. This is a vessel wherein meat is put, with just as much water as will fill it; then the lid is screwed on so close as to admit of no external air. The meat herein is by the flame of a small lamp, in six or eight minutes, brought to a perfect pulp. In a few minutes more the hardest bones are reduced to a jelly. No air entering, the successions caused by the air, enclosed in the flesh, resolve the whole into one homogeneous body: it is just so in digestion. In proportion to its heat the stomach does the very same thing as the digester.

Add to this, that the muscular coat of the stomach continually contracting and pressing its contents by its peristaltic motion, occasions a more intimate mixture, and works the more fluid parts through the pylorus into the duodenum. Along the sides of this and the other small intestines the lacteals are planted: into the minute orifices whereof the chyle or finer part of the mass is received. The lacteal veins of the first kind discharge themselves into the glands of the basis of the mesentery. The chyle is afterward received by the lacteals of the second kind, and conveyed into glands between the two tendons of the diaphragm, and hence it is carried to the heart, where it mixes with the blood.

5. By the perpetual motion of the fluids, (especially in the minute vessels) as well as the constant action of the muscles, small particles are continually

worn off from the solids of the body. The fluids likewise are continually diminishing; and hence every animal body, by the very condition of its frame, is liable to destruction. To prevent this, a restitution must be made to the juices and solids of the body, equal and similar to what is lost, and this we call nutrition.

It seems to be performed thus. The blood forcibly thrown by the heart into the arteries, endeavours to go out every way through the pores. But these are usually too small to give its particles a free passage: they can only pass where any of the pores are open. Here one will naturally follow another in a line, and constitute a fibre or part of a fibre. When as much is thus added to one end of the fibre, as is wasted at the other, the body is nourished; when more is added than is wasted, we are said to grow.

We see then how absolutely necessary food is to repair the constant decay of the body, so that few men or women can live without it above five or six days; and yet the abstaining from it for a season has its use. Indeed great is the efficacy of abstinence, both in prolonging life beyond its usual period, and in the cure of many stubborn disorders.

Lewis Cornaro, a nobleman of Venice, after all other means had failed, so that his life was despaired of at forty, recovered and lived to near a hundred, by mere dint of abstinence.

It is surprising to observe to what an age those ancient christians lived, who retired from the fury of persecution, into the deserts of Arabia and Egypt. They drank only water, and took no other food than twelve ounces of bread in twenty-four hours. On this St. Anthony lived 105 years, Epiphanius 115, Simon Stylites 112, and Romuald 120.

Among animals we see surprising instances of long abstinence. Several species pass four, five, or six months every year without eating or drinking. So tortoises and dormice regularly retire at the season to their respective cells. Some kinds get into ruins or the

hollows of rocks ; others into clefts of trees ; some sleep in holes under the earth, others bury themselves under water.

The serpent-kind bear abstinence to a miracle ; rattle-snakes will subsist many months without food. Dr. Shaw saw two Egyptian serpents which had been kept in a bottle five years, (on a small quantity of sand wherein they coiled themselves up) without any sort of food. Yet when he saw them they had just cast their skins, and were as lively as if just taken.

There have been instances even of men passing several months with scarce any sustenance. So Samuel Chilton, of Tinsbury, near Bath, in the year 1693, 1694, and 1695, slept sometimes four months and sometimes above six together, with very little food ; and six weeks without any but a little tent, conveyed with a quill through his teeth.

And since this, John Ferguson, of Kilmelford, in Argyleshire, about eighteen years ago, overheated himself, drank largely of cold water, and fell asleep. He slept for four and twenty hours, and waked in a high fever ; ever since his stomach loaths and can retain no kind of aliment but water. A neighbouring gentleman to whom his father is tenant, locked him up for twenty days, supplying him daily with water, and taking care that he should have no other food, but it made no difference either in his look or strength. He is now six and thirty years of age, of a fresh complexion, and as strong as any common man.

Still more strange is the case of Gilbert Jackson. About fifteen years of age, in February 1716, he was seized with a violent fever ; it returned in April for three weeks, and again on the 10th of June ; he then lost his speech, his stomach, and the use of his limbs, and could not be persuaded either to eat or drink any thing. May the 17th, 1717, his fever left him, but still he was deprived of speech and of the use of his limbs, and took no food whatever. June 30th, he

was seized with a fever again, and the next day recovered his speech, but without eating or drinking, or the use of his limbs. On the 11th of October he recovered his health, with the use of one of his legs, but neither ate nor drank, only sometimes washed his mouth with water.

On the 18th of June, 1718, the fever returned and lasted till September. He then recovered and continued in pretty good health, and was fresh coloured, but took no kind of meat or drink. On the 9th of June, 1719, he was again seized with a severe fever: on the 10th, at night, his father prevailed on him to take a spoonful of milk, boiled with oatmeal. It stuck so long in his throat, that his parents feared he had been choaked; but ever since that time he has taken food, though so little, that a half-penny loaf serves him for eight days. All the time he fasted he had no evacuation, either by stool or urine, and it was fourteen days after he began to eat before he had any. He is now in pretty good health.

I suppose such another instance as this has scarce been known in the memory of man.

It is not improbable that the air itself furnishes some nutritive particles. It is certain there are substances of all kinds floating in the atmosphere, and that an animal body may be nourished hereby, is evident in the case of vipers. These, if taken when first brought forth, and kept from every thing but air, will yet grow very considerably in a few days.

6. As without respiration 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.

7. In Sight, the action on 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, follows: 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 constricted 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 is filled with small papillæ, which are no other than fine ramifications of the gustatory nerve. 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 stile Tasting.

11. The organ of Feeling 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.

13. 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 the 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. 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 spirits flow through 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 humours, which circulate equally through all the canals. Mean time, all disturbing causes being at rest, the wasted humours 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 foetus sleeps always, children much, youths more than adults, and they 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 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 mind becomes heavy. The powers that hold the body erect, begin to shrink from their office, the eye-lids 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, from 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 flowing to the heart, as warm bathing of the feet, a plentiful ingestion of food into the stomach: likewise whatever lessens the motions of the spirits, 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. The same effect have some fevers, 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 course of the spirits into 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 rises from a defect of the spirits: always from a collapsing of the nervous fibres, through which the spirits 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 spirits on, and prevent the nervous fibres from collapsing.

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 fæces 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 spirits 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 disposition. 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 reasonings, there is nothing but a disjointed huddle of absurd ideas. Instead of well-digested principles, nothing but a disorderly jumble of crude conceptions.

Yet not 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 eyes.

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 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. And as we know Thomas

Parre and Henry Jenkins complicated double that usual term of life, so we have no reason to question that some have doubled the common stature of man. Walter Parsons, King James the First's porter, was full seven feet, seven inches high. Mr. Ray saw a man at Bruges, who was eight feet and a half; all his limbs well shaped, and his strength proportionable. Becanus says he saw a youth almost nine feet high; a man near ten, and a woman quite ten feet. Pliny mentions several men of the same height in his age. Yea, Thevenot tells us that he met a Spanish merchant on the coast of Afric, who had in a coffer the skull and bones of an American giant, which he brought with him from that country, who was eleven feet, five inches in height, and died in the year 1559.

From these warrantable accounts we learn that there have been men 11 or 12 feet high, which equals if not exceeds, the stature of the tallest giant mentioned in scripture. The height of Goliath was but six cubits and a span, which is only nine feet, nine inches. Indeed the bedstead of Og, the king of Basan is said to have been nine cubits in length. But his bed must have been longer than his body; we may fairly allow nine inches above his head, and as much below his feet. And making this deduction, he was not above twelve feet high: much of the same stature with the giant, whose forehead bone, is still kept in the medicine-school at Leyden.

Is this deviation from the common stature of man by largeness, more remarkable than its opposite? The deviation from it by littleness, which has been observed in some instances? Such was the dwarf, who lived for several years in the palace of the king of Poland. His parents were healthy, strong peasants, who affirmed, that at his birth he weighed scarce a pound and a quarter, that he was presented on a plate to be baptized, and for a long time had a wooden shoe for his bed. When 18 months old, he could speak some words, when two years old, he could walk almost

without help. His shoes were then just an inch and a half long. When he was six years of age, the king of Poland gave him the name of Bebe, and kept him in his palace. His height was then fifteen inches, and he weighed thirteen pounds. He was in perfect health, his person was agreeable and well-proportioned; but there was little appearance of understanding. He had no sense of religion, was incapable of reasoning, and could learn neither music nor dancing. Yet he was susceptible of passions in a high degree, anger and jealousy in particular. When sixteen years old, he was 29 inches high, being still healthy and well proportioned, but from that time his health declined; yet he grew four inches in the four succeeding years. At 21 he was shrunk and decrepit; and at 22 it was with difficulty he could walk a hundred steps. In the 23d year he fell into a kind of lethargy, and in a few days died, as if it were of old age.

17. The two most eminent instances of longevity in England were Thomas Parre and Henry Jenkins, Thomas Parre was a poor countryman of Shropshire; whence he was brought up to London, by Thomas, Earl of Arundel. At the age of 120 he married a widow, at 130 he could do any husbandry-work, even threshing of corn, although soon after, his sight began to fail; nor had he the use of his memory, or but in a small degree, for several years before he died: but he retained his hearing and apprehension to the last. He used to eat often, by day and by night, of milk, old cheese, with coarse bread, whey and small beer. He died at the age of a hundred and fifty-two years and nine months. He might have lived much longer, but coming out of a clear, thin, and free air to London, and from a plain country diet, to that of a splendid family, where he fed high, and drank the best wines, the natural functions were overcharged, and death could not but soon ensue.

“Henry Jenkins calling at my house I asked how

old he was? "He paused and said, "about 162 or 163." I asked what was the first public transaction he remembered? He said, "the battle of Flowden-field, being then 11 or 12 years old."

For many years he was a fisherman, and used to wade in the streams. After he was a hundred years old, he frequently swam in the rivers. The latter part of his life, he was obliged to beg. He died at Ellerton upon Swale, in Yorkshire, Dec. 8, 1670 : having lived (supposing him to have been 12 years old, at the battle of Flowden-field, which was fought Sept. the 9th, 1513) a hundred and sixty-nine years that is sixteen longer than Thomas Parre.

CHAP. III.

Of the preternatural State of the Human Body.

1. What the preternatural state of the Body means.
 2. The variety of Diseases.
 3. Reduced to three classes : those of the Solids.
 4. Those of the Fluids, particularly the Blood.
 5. Those of the Animal Spirits.
 6. The remote causes of Diseases.
 7. Of Fevers.
 8. The way to preserve Health.
 9. Of Life and Death.
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1. **W**HEN 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 as 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 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, scirrhus, lethargies, melancholy, hysteric affections: and if at the same time it abounds 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 in 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 to the diseases ascribed to the animal spirits, some are thought to proceed from the suppression or diminution of their motion, as apoplexies and palsies, some from their excessive or irregular motion, as madness, convulsions, epilepsies.

I know not whether the gentlemen of the faculty would not term the following, “a disease of the animal spirits.” Donald Monro, at Strathbogi, in Scotland, imitates unawares all the motions of those he is with: he is a little slender, old man, and was subject to this infirmity from his infancy. He is loath to have it observed, and therefore casts down his eyes in the streets, and turns them aside when in company. We had made several trials before he perceived it, and afterward had much a-do to make him stay. He imitated not only our scratching our heads, but the wringing our hands, and every other motion. We needed not to persuade him to be covered; for he still covered or uncovered as we did, and all so exactly, and

yet with such a natural and unaffected air, that none could suspect he did it designedly. When we held both his hands, and caused another to make such motions, he struggled to get free. But when we would have known more particularly, how he found himself affected, he would only give us this simple answer, That "it vexed his heart and his brain."

But to what class shall we refer the disease of Ann Jackson? She was born at Waterford, of English parents, both said to be sound and healthy, and from three years old, had horns growing on various parts of her body, she is now thirteen or fourteen, the horns grow chiefly about the joints; they are fastened to the skin like warts, and about the roots resemble them much in substance, but toward the end are much harder. At the end of each finger and toe is one, as long as the finger or toe itself, rising a little between the nail and flesh, and bending again like a turkey's claw. On the joints of each finger and toe are smaller ones, which sometimes fall off, but others come in their place. Round her knees and elbows are many; two in particular at each elbow, which twist like rams-horns, at each ear grows one, yet she eats and drinks heartily, sleeps soundly, and performs all the offices of nature, like other healthy persons.

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 scarce 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 skillful 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 slow pulse. Heat succeeds, with a quick, strong, hard pulse, followed by sweat and a 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, chilness 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 tremor 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.

A most unaccountable method of removing many diseases, was that of the famous Mr. Greatrix. "I give you nothing concerning him, says Mr. Boyle, but from eye-witnesses. My own brother some time since was seized with a violent pain in his head and back. Mr. Greatrix coming by accident to our house, gave present ease to his head by stroking it. He then stroked his back, the pain immediately fled to his right thigh. He pursued it with his hand to the knee, ankle, foot, toe, then he stroked this, and it was gone.

"My uncle's daughter was seized with a pain in her knees, which occasioned a white swelling. She tried many remedies without effect, for six or seven years. Mr. Greatrix then coming to Dublin, my aunt brought her to him. He stroked her knees, and the pain fled downward from his hands till he drove it out of her toes. And in a little time the white swelling went away.

"I had an acquaintance, who after a fever was very deaf, and had a violent pain in her ears. Mr. Greatrix put some spittle into her ears and rubbed them, which cured both the pain and deafness.

"Another told me, that when a child she was extremely troubled with the king's evil. She tried many remedies in vain; but Mr. Greatrix stroked and perfectly cured her. A smith near us had two daughters troubled with the same distemper. One of these had a running sore in the thigh, the other in the arm

he cured them both. He cured all kinds of hysteric fits. He likewise cured the falling sickness, and without any relapse, provided he could see the patient in three or four fits."

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 shews 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. Immedi-

ately 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. Mean time 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 compleat 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 govern-

ment 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 secreted 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 three score 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 Parre and Jenkins: yet these men used no particular 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 civilized 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 sage 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 period 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 had 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, than 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 over-stocked with human inhabitants; since, if every person were now 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 providing 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 we are all hastening. All the causes of decay, which have been mentioned, contribute to bring on this dreadful 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 enquire, 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 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 out-living 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 shewn, 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 Frederickschal, 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 shews us, how seldom the one can be suffered, or the other enjoyed to the utmost.

If there be any thing 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 Bruhier 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 was three men to people the earth, their age was cut shorter.

And none of these patriarchs, except Shem, attained to five hundred 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, till 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 inhabitants. If men were now to live 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 is, 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 expences, 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 multi-

tudes 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. But the reverse is true. The inhabitants of the Caribbee islands, usually live a hundred and fifty years. In the Molucca islands, the ordinary life of the natives is a hundred and thirty years. In Sumatra, Java, and the neighbouring islands, the life of the inhabitants commonly extends to a hundred and forty years : in the realm of Cassuby, to 150. The Brasiilians frequently live 160 years, and many, in Florida and Jucatan, still longer.

Nor is this at all improbable. For there being no such inequality of weather in those climates as in ours, the body is not shocked by sudden changes, but kept in a more equal temper. And sickly persons with us, when fixed to their beds, and kept in an equal degree of heat, are often found to hold out many years, who would otherwise scarce have survived one.

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.

CHAP. 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 even 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 over-ruled, 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 then stiled 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 operations : 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 speak 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

can 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 apprehend. 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, be-

tween 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 mix earth, water, air, and fire, 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 tubs, filled with their several humours 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 enjoy his glory. But the manner wherein this was done we cannot tell; this knowledge is too wonderful for us. And it is of 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: the female ovaries, which hang on each side the womb, contain abundance of small vesicles, filled with a transparent liquor. Some suppose, that each of these contains, in miniature, all the parts of a human body: that when one of them is penetrated by the male seed, it is rarified and expanded thereby, till it breaks the membranous shell, and by the fallopian tube, falls down into the womb. Here, being slightly fastened to the sides of the womb, it receives nourishment from the mother, till the heart is formed and begins to propel the blood to the extremities of the still increasing body. When it is come to its full size, by rolling to and fro, it tears asunder the enclosing

membranes, and having burst as it were the prison-bars, emerges into light.

The first thing that appears of a fœtus is the placenta, like a little cloud on one side of the outer coat of the egg. About the same time, the spine becomes visible; and a little after, the brain and cerebellum appear like two small bladders. Next the eyes stand prominent in the head: then the punctum saliens, the heart beating is plainly to be seen; and last of all, the extremities. When formed, the fœtus lying in the womb, is almost of an oval figure. For the head hangs down with the chin upon the breast. Its back is round. With its arms it embraces the knees, which are drawn up to the belly, and its heels are close to the buttocks. Its head is upwards and its face to the mother's belly. About the ninth month, the head, which till then was lighter, becomes heavier than any other part. In consequence of this the head falls down, in the liquor that contains it; the feet get loose, and the face turns toward the mother's back. But being now in an uneasy posture, it struggles and brings on the mother's throes.

Mr. Dodart, nicely observing an embryo, one and twenty days old, found the placenta more than half of the whole; and thence concludes the younger the embryo is, the larger is the placenta in proportion to it: a plain reason, why miscarriages, though the fœtus is less, are more dangerous than regular deliveries. For though the embryo in a miscarriage makes a way sufficient for itself, it does not make a way for so large a placenta as is to follow it.

The embryo itself was only seven lines long, from the top of the head to the bottom of the spine, where it terminated. The thighs were not unfolded: they only appeared like two warts at the bottom of the trunk. The arms made the same appearance on the shoulders. The head was one third of the whole length. On this were two small black points, which would have been eyes. The mouth was very big; a

plain indication that it fed thereby. There was no eminence for the nose ; but two little, almost imperceptible pits for the nostrils. Always the younger the embryo, the bigger the head is, in proportion to the body. The parts nearer the head are likewise bigger, in proportion to the rest.

It weighed less than seven grains, which is an extraordinary lightness, for a body seven lines long. It was so soft that no part of it could be touched, without making a change in its figure. Upon opening it, Mr. Dodart discovered the heart and the right auricle. All the other parts in the thorax and the lower belly, were simple outlines, (all vesicular) except a part on the left side, probably the spleen.

Some suppose, that millions of animalcula swim in the seed of male animals, which are so many embryos, for which a receptacle only is provided in the eggs of the female. But all agree, that either the male seed, or the female egg, contains all the parts of the body ; so that generation is no more than the growth or unfolding of the parts there delineated. But how those seeds, whether male or female, are elaborated and prepared, abundantly transcends the highest reach of human understanding.

If the animalcula, of which all animals are formed, are originally in the male, yet they never can be formed into animals, without the egg of the female.

That all animals spring from animalcula, seems probable from the following considerations :

1. That something may be observed in the tread of an egg, even before incubation, like the rudiments of an animal, in form of a tadpole.

2. That after incubation, all the parts of the animal suddenly appear, the stamina, which existed before, being then expanded. After three days incubation, the punctum-saliens of a chick is discovered by the naked eye. On the fifth day, the rudiments of the head and body appear, which were before discernable

by glasses. After thirty hours, we see the head, the eyes, the heart, and the carina, with the vertebrae distinct. And by glasses we see all those parts, after forty hours, which the naked eye cannot discern till the fifth day. Whence it is probable, that even the first discovery of them by the microscope, is not the discovery of the parts newly formed, but of those that existed before incubation, though not then dilated enough to be visible.

3. That there is a near analogy between animals and plants. Now we know, the seeds of these are only little plants, folded up in membranes. Hence we may easily infer, that animals proceed from animalcula folded up, till they are gradually enlarged and unfolded.

And that these animalcula are originally in the seed of the male, is probable. For 1. Numberless animalcula are observed in the seed of animals. 2. We observe the rudiments of a foetus in eggs fecundated by the male, but not in others. 3. The rudiments in the egg, both before and after incubation, exactly resemble the animalcula in the seed. 4. This gives a rational account of many fetuses at one birth, especially that of the Countess of Holland. It accounts also for a whole cluster of eggs in a hen, being fecundated at once. 5. This best suits the analogy between animals and plants. Every herb and tree bears its own seed; and a little plant of the same kind, which being thrown into the womb of the earth, spreads forth its root and receives its nourishment from the earth, but has its form within itself.

Yet, that no animal can be formed without the egg of the female, is evinced by the following considerations:

1. No animalcula can come forward, if it do not fall into a proper nidus. So though a thousand should fall into one egg, none of them would come forward,

but that which was in the very centre of the cicatricula, or tread. And perhaps the nidus necessary for their formation is so proportioned to their bulk, that it can hardly contain more than one animalcula. This is certainly the case in oviparous kinds. And all the difference between the viviparous and the oviparous is, that in the former, the egg is nothing but the cicatricula with its yolk: so that the fœtus must draw its nourishment from the womb. Whereas, in the oviparous, the egg itself is a kind of womb, containing all that is needful for the animal, till it is hatched,

2. It is acknowledged, that the fœtus in the womb, is not connected with it, for a considerable time after conception: that it is wholly loose from it, and is only a little round egg, with the embryo in the midst, which sends forth its umbilical vessels by degrees, and at last lays hold on the womb. Hence it is plain, that the cicatricula, which nourishes the animalcula, does not spring from the womb, but only falls into it, as a fit soil, whence it may draw nourishment for the fœtus.

Yet there is a difficulty which presses equally on those, who suppose the animal to spring either from the male or female parent. It is the case of monsters. In a mule, for instance: the body is of the form of the mare: whereas the feet, the tail, and the ears, resemble those of its sire. If the male supplied the animalcula, one would imagine the fœtus should always be of the same species with the male. If the female, it should be of her kind: whereas monsters are of both: as if the main part of the animal lay in the egg, and the impregnation only conveyed or changed the extremities.

Yet, that some animals first exist, not in the seed of the male, but wholly in the egg of the female, undeniably appears from the case of frogs and toads. (And why may it not be the same thing with other animals?) The eggs of these are not impregnated by the male, till they issue from the womb. It is while they are ejected, that he fecundates them with his seminal li-

quor. And there is no circumstance, by which the fecundated egg can be known from the unfecundated. It appears that tadpoles exist before fecundation. For the unfecundated eggs do not differ in the least from those that are fecundated. But these are only tadpoles coiled up. Such, therefore, are the unfecundated tadpoles : they exist before fecundation ; only they cannot unfold themselves without the liquid of the male. Frogs then should not be placed among oviparous animals, but among viviparous : if they do not rather constitute a class between both. Thus nature seems to delight in diversifying the modes of animal generation.

This may be the case with regard to one, or perhaps a few species of animals. But, in general, where to place the pre-existent animal or embryo, in the animalcula or the egg, is still the question. A division of vital, essential, and original stamina, is impossible. Yet innumerable instances in monsters, mules, and many natural subjects, concur to prove, that the young partakes of the nature and qualities of both the parents, even to their defects and diseases, which are often hereditary. How then can we suppose unalterable stamina ? Can the visible species of any production be determined by them, if every sensible quality may be influenced indiscriminately by either parent ?

If they are placed in the animalcula or the egg, how are they transmitted ? If in the animalcula, why is the process attended with so vast an expence, so great a waste of millions of entities, each containing a series of the most perfect, and most wonderful productions, when one only of those millions is to take place ? And how are these animals generated ? If in the common way, not only the process will be boundless, (these in their seed will have others, and so on in an endless series ;) but they cannot then be unalterable, because they are capable of being generated. Further, if they float in the air,

or lie hid in food, how is it that the stamina of one species does not sometimes insinuate themselves into a parent of another species? Or if they are excluded, by proper strainers, in distant species, they cannot be so in those that are near akin. For if the spermatic animal, which in the matrix of a mare, produces a horse, is yet so fitted to that of an ass, that it can possess a cellule there, exclusive of every other, which shews an exact co-aptitude; certainly the same animal, if contained in food or air, common to both horse and ass, might pass indiscriminately the strainers of either: and so we might have mules without the promiscuous congress of the two species.

In another view, if we consider the extreme tenuity of one of these stamina, in its first origin at the distance of many ages, compared to the smallest fibre of the animal it is said to constitute: can so minute a filament serve as a substratum for a cylinder, comparatively immense? Can the terraqueous globe derive its present dimensions from the dilatation of an atom? Such is a muscular fibre in its present state, compared to what it was in its origin. Consequently, what must have been the increase of extraneous matter, either by apposition or incorporation, which is now as much a part of the fibre, as the original stamen? And if thus much can be mechanically assimilated, why not the whole formed by mechanical causes? Or why must so insignificant a part of it, be supposed to be concreated with the universe?

The difficulty still increases immensely, if we look into the vegetation of plants, and the wonderful reproduction of the parts of the polypus, lobsters, and many other animals. The original stamina, how minute soever, questionless, are diffused through the whole production: since in this system all animal and vegetable growth is made by developement only. But if diffused, then some or all may be lost by successive

bisection. And if lost, how can they be reproduced? If reproduced, how were they concreated with the universe? These and a thousand other difficulties can in nowise be evaded, but by multiplying supposition on supposition, which renders the hypothesis so complex, as utterly contradicts the ordinary process of nature.

It is more reasonable to say, that so many secretory ducts, so many strainers, so many preparatory vessels in animals, and such a curious disposition in plants, for the continuation of every species, imply a digestion, secretion, and preparation of principles, invariably productive of every individual, when they fall into their respective matrixes, and find aliment proper to assimilate. Are not these principles contained in the nourishment taken by the parent plant or animal, the same that continually vegetate in it, and increase it till it is adult, then exuberate, while it is by new preparations, fitted, invariably to propagate its kind? Else why this digestion? Why this secretion? Why so many strainers, receivers, ducts and valves? And why is some food more productive of these principles than others?

And if every mixed body is made up by the combination of certain principles; we cannot doubt, but God may have established forces in nature, by which such principles may in certain circumstances, be invariably united, without any danger of deviating, so as to render generation equivocal. And if every production in question is a mixed body, we know that how various soever they are, a small number of principles differently combined, will yield variety enough to produce them all. Thus we reduce nature to what it is ever found to be, simple in the beginning of its course, but afterwards, when it is distributed, magnificent beyond expression.

Modern naturalists all agree, that every plant proceeds from its specific seed; every animal from an egg, or something analogous, pre-existing in its parent.

But what do we mean by seeds and eggs? These in the common sense of the words, are certain mixed bodies, that immediately furnish those productions. They are said to contain not only the pre-existent germ, but the fit nidus also and aliment to be assimilated in proper circumstances. They are therefore heterogeneous bodies, that coalesce in a known time; and their principles are so far from being united at the creation, that they sensibly come together from distant places, in all hermaphrodite plants, and from different individuals in all those species, where the male and female are distinct.

But it is in vain for us to lay down any certain rule, and to say to nature, "this is thy scheme; from this thou shalt not deviate." If she makes it a law in many species, that every individual requires the co-operation of a male and female parent; she has, at the same time, her hermaphrodites, both in plants and animals. And if in some hermaphrodites, the sexes are so distinct, that she seems not to deviate far from her primitive law; she will, in another instance, that of the pucerons, act either with or without the co-operation of a male. Again: in some species, the female may be so impregnated, that the impregnation shall diffuse itself to five or six generations. Yet again: in many kinds of polypes, generation proceeds without male or female, egg or seed. And farther still; there are some species of polypes, where a whole family, (after branching out by real vegetation, as far as nature designs) jointly concur to furnish one egg, as the source of a future progeny. If at last you resolve to stand by this, that at least every individual proceeds from a parent like itself; even this is overthrown by late experiments. For we have now a cloud of instances, of a class of beings hitherto unknown, wherein animals grow upon, are produced by, and in the strictest sense of the word, brought forth from plants. Then, by a strange vicissitude, they become plants of another kind. These again become

animals of another, and thus on, for a series farther than the utmost power of glasses can carry the most inquisitive observer.

And as to the animalcula supposed to be discovered in the male seed, the microscope discovers the same in the seminal liquor of females. Probably neither the one, nor the other are real animals, but only inanimate particles in strong fermentation.

PART THE SECOND.

OF BRUTES.

CHAPTER I.

OF BEASTS.

1. The general Difference of Men and Beasts, as to the Structure and Posture of the Body.
 2. Their Agreement.
 3. Their Agreement and Disagreement as to the Head and Brain.
 4. The Heart and Lungs.
 5. The Eyes.
 6. The Ears, Nose, Teeth.
 7. The Windpipe.
 8. The Vegetative and Sensitive Motions in Brutes.
 9. Of the Soul of Brutes.
 10. Of some particular Sorts of Beasts.
 11. Some general Reflections.
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1. **N**EXT to man in the visible creation are Beasts. And certainly, with regard to the structure of the body, the difference is not extremely great between man and other animals, only in this, that the stature of man is erect, and his form more elegant; that no beast has the feet of a man, much less a hand so admirably fitted for every purpose: and lastly, that no

other animal has a brain so large in proportion to its bulk as man. Concerning the prone posture of their body we may observe two things; the parts ministering thereto, and the use thereof.

I. As to the parts, it is observable that in all these creatures; the legs are made exactly conformable to their posture, as those of man are to his posture; and farther, that the legs and feet are always admirably suited to the motion and exercise of each animal. In some they are made for strength, to support a vast unwieldy body; as in the elephant, which being a creature of such prodigious weight, has its legs accordingly made like pillars. In others, they are made for agility and swiftness. So deers, hares, and several other creatures, have their legs very slender, but strong withal, and every way adapted for quick motion. In some, they are formed only for walking and running, in others for swimming too. Thus in the feet of the otter, the toes are all conjoined with membranes, as they are in geese and ducks. And in swimming it is observable, that when the foot goes forward in the water the toes are close, but when backward they are spread out; whereby they more forcibly strike the water, and drive themselves forward. In others, as moles, they are made for walking and digging, and in others for walking and flying.* In some they are made more weak for the plainer lands, in others, stiff and less flexible,† for traversing ice and dangerous precipices. In some they are shod with rough and hard hoofs, in others with only a callous skin.‡ In the latter, the feet are composed of toes;

* The membranous wings of a bat are a prodigious deviation from nature's ordinary way; and so is the Virginian flying squirrel, whose skin is extended in the nature of wings between its fore-legs and body.

† The Elk has legs so stiff and inflexible, that they run on ice without slipping. And this is the way they take in winter to save themselves from the wolves.

‡ The Goat, which generally dwells on mountains and rocks, and delights to walk on narrow ridges, and to take great and seemingly

some short, barely for going ; some long to supply the place of a hand ; some armed with long and strong talons to catch hold and tear the prey ; and some fenced only with short nails to confirm the steps in running and walking.

II. 1. As the posture of man's body is the fittest for a rational animal, so is the prone posture of beasts, the most useful to themselves, and the most fit for the service they perform to man.

2. But there is a wonderful agreement between the bodies of men and beasts, not only with regard to the structure, but also the use of the several parts. How they differ, will be mentioned hereafter.

3. The brain in them is of nearly the same structure and consistence as in man, and undoubtedly performs the same office, secreting the animal spirits (if such there be) in order to sensation and muscular motion in every part of the body. The cerebellum is nearly of the same shape in all ; but the shape of the brain necessarily varies according to that of the head.

It is remarkable that in man the head is of one single form ; whereas in the four-footed race it is as various as their species. It is in some square and large, suitable to their food, abode, and slow motion : in others, it is small, slender, and sharp, agreeable to their swifter motion, or to make way to their food or habitation under ground. And as to the brain contained therein, how small is it in beasts in proportion to what it is in man ! Another thing no less remarkable is, the situation of the brain and the cerebellum. As God has given to man a lofty countenance, and has lodged in his brain an immortal soul, to behold and contemplate heavenly things, so as his face is erect, his brain is set in a higher place, above the cerebellum and

dangerous leaps, has the joints of the legs remarkably stiff and strong ; likewise the hoof is hollow underneath, and its edges sharp.

all the sensories ; but in brutes, whose face is prone to the earth, and who are not capable of speculation, the cerebellum, which ministers merely to animal life, is placed above the brain, also some of the organs of sense are placed, if not above the brain, at least on a level therewith.

Another very great convenience in this position of the brain and cerebellum is, in the head of man, the base of the brain and cerebellum, yea of the whole skull, is set parallel to the horizon, by which means there is the less danger of the two brains joggling or slipping out of the place ; but in beasts, whose heads hang down, the base of the skull makes a right angle with the horizon, by which means the brain is beneath and the cerebellum above. And lest the cerebellum should hereby be liable to frequent concussions, an admirable provision is made by that strong membrane the dura mater, closely encompassing it. Beside this, it is guarded in some species with a strong bony fence. In the hare, the coney and several others, a part of the cerebellum is on each side within the os petrosum, so that its whole mass is, by this double stay, firmly contained within the skull.

4. The heart and lungs in beasts are of the same structure, with the same apparatus of veins and arteries as in men. We cannot therefore doubt but the blood circulates in them, and nutrition is performed as in us. Their food also being dissolved in the stomach, is conveyed by the lacteals to the receptacle of the chyle. To the fore-part of this (in men the upper part) joins the thoracic duct, which extending through the length of the thorax ends in the vein called in beasts *cruralis anterior*. The remaining part of the circulation is performed in them as in men.

But some beasts have more stomachs than one ; and some have the peculiar property of chewing the cud. The food, after it has been swallowed, is returned to the mouth, where it is chewed over again at leisure.

Not that this is altogether peculiar to beasts. There

have been instances of men who had this property. Dr. Slare gives us a particular account of one whom he knew at Bristol. "He begins," says he, "to chew his meat over again, within a quarter of an hour after meals. This chewing, after a full meal, lasts an hour and a half. If he goes to bed soon after a meal, he cannot sleep till the usual time of chewing be over. The victuals returned, taste more pleasantly than they did at first. Bread, flesh, cheese, and drink, are of much such a colour as they would be if mixed together in a mortar. His victuals lie heavy on his stomach till they have passed this second chewing. He was thus ever since he can remember. His father does the same, but in small quantities."—What a mercy is it that we have not more such instances! For how much of our precious time would it consume!

5. The situation, number, and conformation of the eyes in various animals, is wonderfully adapted to their various circumstances. In several the eye looks chiefly forward, but so as to take in nearly the hemisphere before it. In others, the eyes are so placed as to take in nearly a whole sphere. In some, they are so fixed as to look chiefly behind, so that they see their enemy following them; so in rabbits and hares: whereas in dogs they are more forward, to look after their prey.

Generally the head is moveable for the sake of the eyes, and the eyes themselves moveable every way. Where it is not so, other expedients are found to answer the same end. Thus in some creatures the eyes are set at a distance from the head, to be moved this way or that: as in snails, whose eyes are fixed to the end of their horns, or rather of the optic nerves which are sheathed therein. In other creatures, whose heads and eyes are immoveable, this is made up by the number of eyes. So spiders, which cannot move their head, have four, six, or eight eyes, all placed in the front of the head (which is round) like a locket of diamonds.

Many animals have muscles to move the eye, and obvert it to the object. Fishes have none; but for amends they have many little protuberances finely ranged on their large bulging eyes, by which numberless rays of light are deflected from objects above, beneath, and on either side. Yea, some hundreds of these protuberances are curiously ranged on the convex eye of a Flesh-fly.

Scorpions have above a hundred eyes; an Ephemeron fly full two thousand.

In other creatures which have only two eyes, the want of motion therein is supplied by their eyes protuberating into hemispheres, each being a vast number of segments of a sphere.

The eyes of a Cameleon resemble a convex glass set in a round socket, which he turns backward and forward without stirring the head, and commonly one a contrary way to the other.

Lastly, Moles living under ground, have not so much need of eyes as other creatures; yet they have eyes, but exceeding small, far in the head, and covered with strong hair. When they are above ground they can put them forth beyond the skin, and draw them back at pleasure.

Another circumstance relative to the eye is highly remarkable. As we use various apertures to our optic glasses, so nature has made a far more compleat provision to admit enough, and not too much light into the eyes of animals, by the dilatation and contraction of the pupil. And this, in divers animals of divers forms, is according to their peculiar occasions. In some it is round, particularly in man, that being the most proper figure for the position of our eyes, and the use we make of them both by day and night. In some animals it is of a longish form, in some transverse, with its aperture large (an admirable provision for their seeing side-ways) and thereby avoiding many inconveniencies, as well as a help for gathering their food on the ground, whether by day or night. In others, that aperture is erect, and also capable of opening wide.

and shutting close. The latter serves to exclude the bright light of the day, the former to take in the faint rays of the night, thereby enabling them to see and catch their prey when there is no light discernable to us.

Thus cats can so close their pupil as to admit but a single ray of light ; and again, by throwing all open, they can take in all the faintest rays ; which is an incomparable provision for creatures that have occasion to watch their prey both by day and night.

But beside this, in cats and other nocturnal animals, there is a sort of carpet at the bottom of the eye, which gives a kind of radiation on the pupil, thereby enabling them to see in the dark.

To preserve this tender organ, many creatures have a membrane, which is not commonly perceived, where-with they can at pleasure cover the eye, without too much hindering the sight, being both transparent and strong, so that it is a kind of moveable cornea.

Providence is conspicuous in furnishing frogs with this ; for as they live in watry places which generally abound in plants that have sharp edges or points, and as the frog goes on, not by walking but by leaping, if he were not so furnished, he must either shut his eyes, and so leap blindfold, or run many risques by leaving them open ; but this membrane guards the eyes without blinding him, and as soon as the occasion for it is over, he draws it back into a little cell. Many birds also, as they must fly between trees and bushes, are provided with the same membrane, and so is the reindeer.

6. The comparative anatomy of the Ear, yields abundant instances of the Creator's wisdom. In birds the outward ear is close and covered, not protuberant, as that would obstruct their flight. In beasts, its form is agreeable to the posture and motion of the body, but admirably varied in the several species according to their various occasions. In some, as the hare, it is large, open, and erect, by which means

that timorous helpless creature is warned of the least approach of danger. In others, it is covered to keep out noxious bodies. In those which are forced to mine and dig for their habitation, it is short, and lodged deep and backward in the head. Thus moles have no auricle at all, but only a round hole between the neck and shoulder, and this is closed with a little skin, which opens and shuts like an eye-lid. The sea-calf also, as well as lizards and serpents, have no outward ear, and the tortoise, with most kind of fishes, have the passage quite covered over.

But among all the varieties in the structure of this organ, none are more remarkable than those of the passage into the *os petrosum*. In an owl, which perches upon a tree or beam, and hearkens after the prey beneath her, it comes farther out above than below, for the better reception of sounds from beneath. In a fox, which scouts under the prey at roost, it comes farther out below than above. In a pole-cat, which hearkens straight forward, it is produced behind, for the taking a forward sound. Whereas a hare, whose enemy comes behind, is supplied with a bony circle directed backward, by means of which she receives distinctly the smallest sound which comes that way.

The more accurate the sense of Smelling is in any creature, the longer are the *laminæ* in the nostrils, and the more in number, folded up and crowded together, to contain more nervous filaments, and to detain the odoriferous particles in their windings and turnings. An admirable provision this for the good of many creatures, the chief acts of whose lives are performed by the ministry of this sense. In insects and many other creatures it is of great use, in helping them to proper places for hatching their eggs, and breeding up their young: and most irrational animals, beasts, birds, and reptiles, do by their smell find out their food. With what sagacity do some of them discover it, in the midst of mud and dirt. How curiously do others pick and chuse such plants as afford them wholesome

food (perhaps medicine too) avoiding such as tend to hurt or destroy them. And all this principally by the smell, together with its near ally, the taste.

The various forms of the Teeth in various creatures, is another instance of the Divine wisdom. How curiously are they adapted to the peculiar food and occasion of each species! Thus in the rapacious, they are fitted to catch and hold their prey; in the herbaceous, to gather and chew vegetables. In those which have no teeth, as birds, the bill supplies that defect, together with their additional stomach. And it is a remark which hardly fails, all such animals as have four stomachs have no teeth at all.

There are great varieties in the teeth of other animals: trout have teeth upon their tongues; cod-fish at the bottom of their gullet. Crocodiles have three rows of teeth on the same jaw; sharks four or five: sea-devils, so called, have several rows of moveable teeth.

7. The variation of the Wind-pipe in various creatures is likewise observable, as it is necessary for that of the voice. In a hedge-hog, which has a very small voice, it is hardly more than membranous. In a pigeon, which has a low soft note, it is partly membranous, partly cartilaginous. In an owl, which has a good audible note, it is more cartilaginous: but that of a jay (as of a linnet) has bones instead of cartilages.

The rings of the wind-pipe likewise are fitted for the modulation of the voice; for in dogs and cats, which use a great many notes, they are (as in man) open and flexible, whereby all or any of them is more or less dilated or contracted, in order to a deeper or shriller note. But they are one entire ring in the Japan peacock, which uses one single note.

8. As to the Motions of brutes it is not easy to conceive that even those of the vegetative kind, can be the mere mechanical effects of matter, however modified; much less can we conceive this of their sensitive

motion, for we have not the least reason to doubt but the same impressions of external objects raise the same perceptions in them as in us. No question, they see, and hear, and smell, and taste, and feel in the same manner as men!

9. We cannot therefore deny, that there is something in brutes which perceives the impressions made by outward objects; and that they perform a thousand actions which can never be explained by mere mechanism, those in particular which spring from what we call instinct, as the feeding and tending their young, the building their nests and preparing their habitation, upon or in the earth.

It is true, some things in brutes as well as in men may be mechanically accounted for, but others cannot; so that we are constrained to own there is in them also some superior principle, of whatever kind it be, which is endued with sense, perception, and various appetites: for from their outward actions we may as easily learn, as we could from those of a man born deaf and dumb, that there are in this principle or soul two different faculties—that of perceiving or knowing, answerable to our understanding, and that of desiring and shunning, answerable to our will. That this principle is immaterial appears from this single consideration, it has a power of self-motion, which no matter can have, being wholly and essentially passive.

10. It is not my design to enumerate the several species of beasts, but it may illustrate the wisdom of the great Creator to give some account of a few, several of which are not so commonly known.

The largest land animal in the world is an Elephant, which seems rather to belong to the hog-kind than any other; they are found only in the south of Afric, and in the East-Indies, and are generally of a dark colour. Their eyes are like those of a hog: at the corners of their mouth grow two large teeth, six or seven feet

long in the male, but not above one in the female. They feed on grass, nuts, and other vegetables.

Of all quadrupeds the elephant is the strongest as well as the largest ; and yet in a state of nature it is neither fierce nor formidable. Mild, peaceful, and brave, it never abuses its strength, and only uses it for its own protection. In its native deserts the elephant is a social friendly creature. The oldest of the company conducts the band, that which is next in seniority brings up the rear. The young, the weak, and the sickly, fall into the centre, while the females carry their young. They maintain this order only in dangerous marches, or when they desire to feed in cultivated ground : they move with less precaution in the forests and solitudes, but without ever removing far asunder.

Nothing can be more formidable than a drove of elephants, as they appear at a distance in an African landscape : wherever they march, the forest seems to fall before them : in their passage they bear down the branches on which they feed ; and if they enter into an enclosure, they destroy all the labours of the husbandman in a very short time. Their invasions are the more disagreeable because there is no means of repelling them : since it would require a small army to attack the whole drove when united. It now and then happens that one or two is found lingering behind the rest, and it is against these that the art and force of the hunters are united ; but an attempt to molest the whole body would certainly prove fatal. They go forward directly against him who offers the insult, strike him with their tusk, seize him with their trunks, fling him into the air, and then trample him to pieces under their feet. But they are thus dreadful only when they are offended, and do no manner of personal injury, when suffered to feed without interruption.

The elephant has very small eyes when compared to the enormous bulk of its body ; but though their minuteness may at first sight appear deformed, yet, when

we come to examine them, they are seen to exhibit a variety of expression. It turns them with attention and friendship to its master; it seems to reflect and deliberate; and as its passions slowly succeed each other, their various workings are distinctly seen. It is remarkable for the excellence of its hearing: its ears are extremely large, they are usually dependent, but it can readily raise and move them: they serve also to wipe its eyes, and to protect them against the dust and flies. It appears delighted with music, and readily learns to beat time, to move in measure, and even to join its voice with the drum and trumpet.

This animal's sense of smelling is not only exquisite, but it is pleased with the same odours that delight mankind. The elephant gathers flowers with great pleasure; it picks them up one by one, unites them in a nosegay, and seems charmed with the perfume. The orange flower is particularly grateful, both to its taste and smell; it strips the tree of all its verdure, and eats every part of it, even to the branches themselves. It seeks in the meadows the most odoriferous plants to feed upon, and in the woods it prefers the coco, the banana, the palm, and the sage tree to all others.

But it is in the sense of feeling that this animal excels all others of the brute creation, and perhaps man himself. The organ of this sense is wholly in the trunk, which is an instrument peculiar to this animal, and that serves it for all the purposes of a hand. The trunk ends in two openings, or nostrils, like those of a hog. An elephant of fourteen feet high has the trunk about three feet long, and five feet and a half in circumference, at the mouth. It is hollow all along, but with a partition running from one end of it to the other. This tube is composed of nerves and muscles covered with a skin like that of the rest of the body. It is capable of being moved in every direction, of being lengthened and shortened, of being bent or straightened; so pliant as to embrace any body it is applied to, and yet so strong that nothing can be torn from its gripe. To aid the force of this grasp, there are

several very little eminences like a caterpillar's feet on the under-side of this instrument, which without doubt contributes to the sensibility of the touch as well as the firmness of the hold. Through this trunk the animal breathes, drinks, and smells; and at the very point of it, just above the nostrils, there is an extension of the skin, above five inches long, in the form of a finger, and which, in fact, answers all the purposes of one; for with the rest of the extremity of the trunk it is capable of assuming different forms at will, and consequently of being adapted to the minutest objects. By means of this, the elephant can untie the knots of a rope, unlock a door, and even write with a pen. It sometimes happens, that the object is too large for the trunk to grasp, in such a case the elephant makes use of another expedient, it applies the extremity of the trunk to the surface of the object, and, sucking up its breath, lifts and sustains such a weight as the air in that case is capable of keeping suspended. In this manner this instrument is useful in most of the purposes of life; it is an organ of smelling, of touching, and of suction; it not only provides for the animal's necessities, but it also serves for ornament and defence.

The legs are not so inflexible as the neck, yet they are very stiff, and bend not without difficulty. Those before seem to be longer than the hinder, but, upon being measured, are found to be something shorter. The joints by which they bend are nearly in the middle, like the knee of a man, and the large bulk which they are to support makes their flexure ungain. Yet while the elephant is young it bends the legs to lie down or rise, but when it grows old or sickly this becomes so inconvenient that the animal chuses to sleep standing.

It is one of the striking peculiarities of this animal, that his generative powers totally fail when he comes under the dominion of man; as if he seemed unwilling to propagate a race of slaves to increase the pride of his conqueror.

The elephant, when once tamed, becomes the most

gentle and obedient of all animals. It soon conceives an attachment for the person that attends it, caresses him, obeys him, and seems to anticipate his desires.

In a short time it begins to comprehend the signs made to it, and even the different sounds of the voice; it perfectly distinguishes the tone of command from that of anger or approbation, and acts accordingly. It receives its orders with attention, eagerly, yet without precipitation. All its motions are regulated, and its actions seem to partake of its magnitude, being grave and majestic. It is quickly taught to kneel down to receive its rider; it caresses those it knows with its trunk; with this salutes such as it is ordered to distinguish, and with this, as with a hand, helps to take up part of its load. It suffers itself to be arrayed in harness, and seems to take a pleasure in the finery of its trappings. It draws either chariots, cannons, or shipping, with surprising strength and perseverance; and this with a seeming satisfaction, provided its master appears pleased with its exertions: and he frequently takes such an affection for his keeper that he will obey no other; and it has been known to die for grief, when in some sudden fit of madness it has killed its conductor.

In Deli, an elephant passing the streets, put his trunk into a taylor's shop, where several people were at work. One of the persons of the shop, desirous of amusement, pricked the animal's trunk with his needle. The elephant passed on without any signs of resentment, but coming to a puddle of dirty water, filled his trunk, returned to the shop, and spurted it over all their finery.

Some of them are twenty feet in compass, and near fourteen high. They seem to have more sense than any other brute, and are capable of fidelity and strong affection, particularly to their companion, so that neither the male nor female is ever known to make a second choice.

The female goes seventeen months with her young: they are fifty or sixty years before they have their full

strength, are in full vigour at about a hundred, and live two or three hundred years.

A Rhinoceros, next to the elephant, is the most extraordinary animal in the Indies. It is usually twelve feet long, from the tip of the nose to the insertion of the tail, from six to seven feet high, and the circumference of its body is nearly equal to its length. It is therefore equal to the elephant in bulk, and if it appears much smaller to the eye, the reason is, the legs are much shorter. In other respects it is shaped like a wild-boar.

It is said to have a very rough tongue, but this is so far from the truth, that no animal of near its size has so soft a one. It is smooth and small like that of a dog; and to the feel, it appears as if one passed the hand over velvet. It has a peculiar cry, a mixture between the grunting of a hog and the bellowing of the calf. The age of these animals is not well known: it is said by some that they bring forth at three years old, and if we may reason from analogy, it is probable they seldom live above twenty.

That which was shewn in London, was said by its keeper to be eighteen years old, and even at that age he pretended to consider it as a young one; however it died shortly after, and that probably in the course of nature. It is a native of Asia and Africa, and is usually found in those extensive forests that are frequented by the elephant and lion. As it subsists entirely upon vegetable food, it is peaceful and harmless among its fellows of the brute creation; but though it never provokes to combat, it equally disdains to fly. It is every way fitted for war, but rests contented in the consciousness of its security.

His skin is without hair, and so full of scratches and scabs, that at a distance they may well be taken for scales. On his nose he has a horn of a dark brown colour, which bends backward, and is often two feet long. He has often another horn a little above this, which never exceeds six inches. His eyes are exceed-

ing small, and he only sees strait forward ; therefore he always runs in a strait line, tearing up whatever stands in his way. With his horn he throws stones over his head to a great distance, and even tears up trees by the roots.

The outer skin of the Rhinoceros, which consists of many folds, is thick and impenetrable. In running one's fingers under one of the folds, it feels like a piece of board half an inch thick ; but between the folds the skin is as smooth and soft as silk, and easily penetrated.—See here the wisdom of the great Creator ! If the outer skin, which is quite inflexible, was continued all over him without any fold, he could not perform any action whatever ; but the suppleness of skin in other beasts, is compensated in this by these folds. It was necessary his skin should be hard for his defence : mean time, it was a noble contrivance that it should be so soft and smooth underneath, that when he bends himself any way, one part of this board-like skin, should slide over the other. And these folds are placed in such parts of his body as to facilitate the performance of every voluntary motion.

Another native of the East Indies is the Camel, one of the most serviceable animals in the world. He kneels down to receive his burden, and rises when he hath his accustomed load. If he feels himself over-burdened, he will not rise, but cry till part of it is taken off. One of them will carry a thousand or twelve hundred weight, forty miles a day, for thirty or forty days together. They have no teeth in the upper jaw. They will travel forty hours without either meat or drink, and nine days without drink : they have two stomachs admirably contrived for this purpose. The gentleman who dissected one at Paris, found in his second stomach several square holes, which were the orifices of about twenty cavities, made like sacks, placed between the two membranes, which compose the substance of the stomach. And in these reservoirs he contains water enough to serve him for so many days.

The bunch on his back is not flesh, much less bone, but mere hair ; and when this is pressed close down, he is no more hunch-backed than a swine. They subsist on very little, which enables them to travel through those vast and barren deserts.—How wise is he who caused these to be natives of those countries where such creatures are absolutely necessary ! A farther instance of this is, that the African camel, which has still greater and more uncounted journeys to take, is larger and stronger, and capable of carrying heavier burdens than those of Asia.

Another wonderful property of camels is, that of foreseeing the poisonous winds, which kill in a moment. A little before these come, they run together and cry, and hide their noses in the earth ; and as soon as they are past, they lift up their heads, and continue their journey.

The Dromedary in most respects resembles the camel, only it is of a slighter make, and instead of one bunch on its back has two, about six inches in height. It goes frequently forty leagues a day ; so that although it cannot carry above six hundred weight, yet its swiftness atones for its weakness. Its feet are soft as a sponge, and are not hurt either by stones or sand. And (what is an excellent providence) they travel best and have the greatest spirits in the hottest weather.

The Lamas, in Peru, have small heads, resembling in some measure both a horse and a sheep. The upper lip is cleft like that of a hare, through which, when they are enraged, they spit, even to ten paces distance, a sort of juice, which when it falls upon the skin, causes a red spot and great itching. The neck is long like that of a camel, the body like that of a sheep, but with much longer legs. It yields strong and fine wool, and is also a beast of burden, and kept at an easy expence. It carries a burden a vast way without tiring ; eats very little, and never drinks. At

night he lies down, and no blows can make him rise, or move one foot till morning.

A creature no less remarkable, but in a quite different way, is the Castor or Beaver. This creature is about four feet long, and fifteen inches broad: he is covered with two sorts of hair, one long, the other a soft down. The down, an inch long, is properly his cloathing, being extremely fine, and close laid upon the skin. The long hair is spread over all, to preserve it from dirt and wet.

Whether male or female, it has two bags under its belly, which contain a liquid substance that congeals in air, and affords an excellent medicine, which we call Castoreum.

He has strong teeth rivetted fast in his jaws, to cut wood, as well as chew his food. His fore-feet are like those of an ape or squirrel, to hold what he eats in his paw, and with these he digs, softens and works the clay or loam for his habitation. His feet are remarkably formed, more proper to swim than to walk with, the five toes being joined together by a strong membrane. His tail is long, flattish, covered with scales, and constantly lubricated with oil; because, being an architect from his birth, he uses his tail as a hod, to carry his clay or mortar, and as a trowel to spread it into an incrustation. Mean time the scales preserve it from being hurt by the burden; and the oil which he squeezes from his bags, and rubs on with his snout, from the noxious air and water.

As they like to live together, they chuse a situation near some rivulet. They first build a causeway, in which the water may rise level with the first story of their habitation. This is built of wood and clay, twelve feet thick at the bottom, descending in a slope on the side next the water. The other side is perpendicular: the top of this is about two feet broad. They cut their wood, though as thick as one's thigh, into pieces, from two to six feet long, drive them into the earth with their teeth, and lace them together with

boughs, closing all the opening within and without with a strong plaister made of clay. If the water increase upon them, they raise their wall higher. Knowing their materials are more easily brought by water than by land, they watch its increase, to swim with mortar on their tails, and stakes between their teeth, to the place where they build. When the causeway is finished, they begin their apartments, which are oval, and divided into three partitions, one above another; but the walls of these are perpendicular, and only two feet thick. All the wood that projects, they cut off with their teeth, and rough-cast both the out and inside of their work, with a mixture of clay and dry grass. The first partition being below the level of the dyke, is full of water, for they love to have their hinder part hanging in the water. The other two are above it, so that if the water ascend, they may ascend proportionably.

At the bottom of their building, they strike out two openings to the stream; one leads to the place where they bathe, the other to that where they ease nature.

They associate ten or twelve together, and proportion their house to their number. When all is finished below, they vault the top or roof in an oval form.

In summer they feed on fruits and plants, in winter on willow, ash, or other wood. This they collect and store up in time. They cut boughs from three to six feet long: the large pieces are brought to the magazine by several beavers, the smaller by one alone; but they take different ways, each having his path assigned, to prevent the labour being interrupted. They build up their pile with much art, which is proportioned to their number. A square pile of thirty feet, about ten feet deep, serves for ten beavers; but the wood is not piled up in one continued heap, the pieces are laid across one another, with cavities between for the convenience of drawing out what they want. They always use first the parcel at bottom which lies in the water, and when it is taken up for use, they cut this wood into small pieces, and convey it to their apart-

ment, where the whole family come and receive their shares.

The feet of a female beaver, which a gentleman kept in England some years since, were webbed like those of a goose. The tail was scaly, and shaped like the blade of an oar; this she used as a rudder to steer herself, especially when she swam under water, which she would do for two or three minutes, and then come up to take breath, sometimes raising only her nostrils above water. She swam swifter than any water fowl; and under water as swift as a carp. The hind legs being longer than the fore, make her walk slow on dry land, or rather waddle like a duck. If drove along fast, she could not run, but went by jumps, flapping her tail against the ground. She never made any noise except a little sort of a grunting, when angry or driven fast. As the beaver frequents the water like waterfowls, may not the castor be provided for him by nature to anoint his fur with, and to prevent the water from soaking to his skin; and as it is impregnated with penetrating pungent particles, it may likewise contribute to keep off the chill, which the water might otherwise strike to his body when he remains long therein.

The Shammoy, though a wild animal, is easily tamed, and is to be found only in rocky and mountainous places. It is about the size of a domestic goat; it is agreeably lively and active beyond expression. The Shammoy's hair is short like that of the doe. In spring it is of an ash-colour, in autumn, a dun colour, inclining to black, and in winter, of a blackish brown. This animal is found in great plenty in the mountains of Dauphiny, of Piedmont, Savoy, Switzerland, and Germany. They are peaceful gentle creatures, and live in society with each other. They are found in flocks of from four to fourscore, dispersed upon the crags of the mountains. The large males are seen feeding detached from the rest, except in rutting time,

when they approach the females, and drive away the young.

It is to be observed, that this creature is extremely vigilant, and has an eye the most piercing in nature. Its smell also is not less distinguishing. When it sees its enemy distinctly, it stops for a moment, and then, if the person be near, in an instant flies off. In the same manner it can by its smell discover a man at a great distance, and gives the earliest notice. Upon any alarm, the shammoy begins his hissing note with such force, that the rocks and the forests re-echo to the sound. The animal having reposed a moment, again looks round, and perceiving the reality of its fears, continues to hiss by intervals. During this time it seems in the most violent agitation; it strikes the ground with its fore-foot, and sometimes with both: it bounds from rock to rock; it turns and looks round; it runs to the edge of the precipice, and still flies with all its speed.

Its head is furnished with two small horns of about half a foot long, of a beautiful black. The ears are placed in a very elegant manner, near the horns, and there are two stripes of black on each side of the face, the rest being of a whitish yellow, which never changes. They run along the rocks with great ease and indifference, and leap from one to another, so that no dogs are able to pursue them. They always mount or descend in an oblique direction, and throw themselves down a rock of thirty feet, and light with great security upon some excrescence or fragment on the side of the precipice, which is just large enough to place their feet upon. The more craggy and uneven the forest, the more this animal is pleased with the abode, which thus adds to its security.

The Roe-Buck is the smallest of the deer-kind in our climate, and is now almost extinct, except in the Highlands of Scotland. It is generally about three feet long, and about two feet high. The horns are

from eight to nine inches long, upright, round, and divided into three branches. The body is covered with very long hair, well adapted to the rigour of its mountainous abode.

As the stag frequents the thickest forests, and the sides of the highest mountains, the roebuck courts the shady thicket, and the rising slope. Although far inferior in strength to the stag, it is more active, and even more courageous. Its hair is always smooth clean, and glossy; and it frequents only the driest places, and of the purest air. Though but a very little animal; yet, when its young are attacked, it faces the stag himself, and often comes off victorious. All its motions are elegant and easy; it bounds without effort, and continues the course with little fatigue. It is also possessed of more cunning in avoiding the hunter: and, although its scent is much stronger than that of the stag, it is more frequently found to make good a retreat. The stag never offers to use art until his strength is beginning to decline; this more cunning animal, when it finds that its first efforts to escape are without success, returns upon its former track, again goes forward, and again returns, until by its various windings, it has entirely destroyed the scent, and joined the last emanations to those of its former course. It then by a bound, goes to one side, lies flat upon its belly, and permits the pack to pass by very near, without offering to stir.

The roe-buck differs from the stag also, in its natural appetites, its inclinations, and its whole habit of living. Instead of herding together, these animals live in separate families, the sire, the dam, and the young ones associate together, and never admit a stranger into their little community. All others of the deer-kind are inconstant in their affection; but the roe-buck never leaves its mate: and as they have been generally bred up together, from their first fawning, the male and female never after separate.

They drive away their fawns upon these occasions, the buck forcing them to retire in order to make

room for a succeeding progeny. However, when the season is over, the fawns return to their does, and remain with them some time longer ; after which, they quit them entirely, in order to begin an independent family of their own.

When the female is ready to bring forth, she seeks a retreat in the thickest woods, being not less apprehensive of the buck, from whom she then separates, than of the wolf, the wild cat, and almost every ravaging animal of the forest. She generally produces two at a time. In about ten or twelve days these are able to follow their dam, except in cases of warm pursuit, when their strength is not equal to the fatigue. Upon such occasions the tenderness of the dam is very extraordinary, leaving them in the deepest thicket she offers herself to the danger, flies before the hounds and does all in her power to lead them from the retreat where she has lodged her little ones. Such animals as are nearly upon her own level she boldly encounters ; attacks the stag, the wild cat, and even the wolf ; and while she has life, continues her efforts to protect her young.

Of all animals of the deer kind, the rein-deer is the most useful. It is a native of the icy-regions of the North, and cannot live in a more southern climate. Nature seems to have fitted it entirely for that hardy race of mankind that live near the pole. As these would find it impossible to subsist among their barren, snowy mountains, without its aid, so this animal can live only there. From it alone, the natives of Lapland and Greenland supply most of their wants. It answers the purposes of a horse, to convey them and their scanty furniture, from one mountain to another ; it answers the purposes of a cow, in giving milk ; and of the sheep, in furnishing them with a warm, though a homely kind of clothing. From this alone, therefore, they receive as many advantages, as we derive from three of our most useful creatures. It is lower and stronger built than the stag ; its legs are shorter and thicker, and its hoofs

much broader ; its hair is much thicker and warmer, its horns much larger in proportion, and branching forward over its eyes, its ears are much larger ; its pace is rather a trot than a bounding, and this it can continue for a whole day ; its hoofs are cloven and moveable, so that it spreads them abroad, as it goes, to prevent its sinking in the snow.

Lapland is divided into two districts, the mountainous, and the woody. The mountainous part is barren and bleak, excessively cold, and uninhabitable, during the winter. Still, however, it is the most desirable part of this frightful region, and is most thickly peopled, during the summer. The natives generally reside on the declivity of the mountains, three or four cottages together. Upon the approach of winter, they migrate into the plains below, each bringing down his whole herd, which often amounts to more than a thousand, and leading them where the pasture is in greatest plenty. The woody part of the country is much more hideous : a frightful scene of trees without fruit, and plains without verdure. As far as the eye can reach, nothing is to be seen even in the midst of summer, but barren fields, covered only with moss, no grass, no flowery landscapes, only here and there a pine tree, which may have escaped the frequent conflagrations, by which the natives burn down their forests. This moss, however, which deforms the country, serves for its only support, as upon it alone the rein deer can subsist. The inhabitants, who, during the summer, lived among the mountains, drive down their herds in winter, and people the plains and woods below.

There is something worthy our notice even in that despised animal, an ass. There is a much greater resemblance between the horse and the ass, than between the sheep and the goat. And yet the latter produce an animal, that is not barren ; whereas the mule always is.

The She-ass is not less fond of her young, than the

male is of her. She will rush either through fire or water, to protect or rejoin it. An ass is often no less attached to his owner. He scents him at a considerable distance, he distinguishes him from others, in a crowd. He knows the way wherein he has passed and the places where he inhabits.

When over-loaded he shews it by hanging down his head, and lowering his ears. If his eyes are covered, he will not stir a step; and if he is laid down in such a manner that one eye is covered with the grass, while the other is hidden with a stone, or whatever is next at hand, he will continue fixed in the same situation, and will not so much as attempt to rise, to free himself from those slight impediments. He walks, trots, and gallops like a horse, but is soon tired, and then no beating will mend his pace. It is in vain that his unmerciful rider exerts his whip or his cudgel: the poor little animal bears it all with patience, and does not offer even to move.

The Spaniards, of all people in Europe, seem to be acquainted with the value of the ass. They take all precautions to improve the breed, and a jack-ass in Spain is above fifteen hands high. This animal, however, seems originally a native of Arabia. A warm climate is known to produce the largest and the best, their size and spirit decline, in proportion as they advance into colder regions.

In Guinea, they are larger and more beautiful, than even the horses of the same country.

In Persia, they have two kinds; one of which is used for burthens, being slow and heavy, the other is kept for the saddle, being smooth, stately, and nimble. An ass will live above sixty years. He sleeps much less than the horse; and never lies down for that purpose, unless very much tired. The she-ass goes above eleven months with young, and never brings forth more than one at a time.

The mule may be engendered, either between a horse

and a she-ass, or between a jack-ass and a mare. The latter breed is every way preferable, being larger, stronger, and better shaped. The common mule is found very serviceable in carrying burthens, particularly in mountains and stony places. Their manner of going down the precipices of the Alps is very extraordinary. In these passages, on one side, are steep eminences, and on the other, frightful abysses; and, as they generally follow the direction of the mountain, the road, instead of lying in a level, forms at every little distance steep declivities, of several hundred yards downward. These can only be descended by mules, and the animal itself seems sensible of the danger. When they come to the edge of one of these descents, they stop of themselves without being checked by the rider; and, if he inadvertently attempts to spur them on, they continue immovable. They seem ruminating and preparing themselves for the encounter. They not only attentively view the road, but tremble and snort. Having prepared for the descent, they place their fore-feet in a posture, as if they were stopping themselves; they then put their hinder feet together, but a little forward, as if they were going to lie down. In this attitude, having taken as it were a survey of the road, they slide down with the swiftness of a meteor. In the meantime, all the rider has to do, is to keep himself fast on the saddle, without checking the rein, for the least motion is sufficient to disorder the mule; in which case they both unavoidably perish. But their address in this rapid descent, is truly wonderful; for in their swiftest motion, when they seem to have lost all government of themselves, they follow exactly the different windings of the road, as if they had previously settled in their minds the route they were to follow.—In this journey, the natives who are placed along the sides of the mountains, and hold by the roots of the trees, animate the beast with shouts, and encourage him to perseverance.

There are but three animals of the horse kind. The Horse, which is the most stately and courageous, the Ass which is the most patient, and the Zebra which is the most beautiful, but at the same time the wildest animal in nature. Nothing can exceed the delicate regularity of this creature's colour or the smoothness of its skin ; but on the other hand, nothing can be more timid, or more untameable.

The Zebra, or wild-ass, is chiefly a native of the southern parts of Africa, and there are whole herds of them often seen feeding in the extensive plains near the Cape of Good Hope. However, their watchfulness is such, that they suffer nothing to come near them ; and their swiftness so great, that they readily leave every pursuer far behind. The zebra, in shape, rather resembles the mule than the ass. Its ears are not so long as those of the ass, and yet not so small as in the horse-kind. Like the ass its head is large ; its back straight, and its tail tufted at the end ; like the horse, its skin is smooth and close, and its hind quarters round and fleshy. But its great beauty lies in the amazing elegance of its colours. In the male, they are white and brown ; in the female white and black. These colours are disposed in alternate stripes over the whole body, and with such exactness and symmetry, that one would think nature had employed the rule and compass to paint them. These stripes which, like so many ribbons are laid all over its body, are narrow, parallel, and exactly separated from each other.

It is now not known, what were the pains and the dangers which were first undergone to reclaim the breed of horses from savage ferocity, these no doubt made an equal opposition ; but by being opposed by an industrious and enterprising race of mankind, their spirit was at last subdued, and their freedom restrained.

It is otherwise with regard to the zebra : it is the

native of countries where the human inhabitants are but little raised above the quadruped. The natives of Angola or Cafraria, have no other idea of advantage from horses, but as they are good for food; neither the fine stature of the Arabian courser, nor the delicate colourings of the zebra, have any allurements to a race of people who only consider the quantity of flesh, and not its conformation. The delicacy of the zebra's shape, or the painted elegance of its form, are no more regarded by such, than by the lion that makes it his prey. Perhaps the zebra may have hitherto continued wild, because it is the native of a country where there have been no efforts made to reclaim it. All pursuits then were rather against its life than its liberty; the animal has thus been long taught to consider man as its mortal enemy: and it is not to be wondered, that it refuses to yield obedience where it has so seldom experienced mercy.

All animals seem perfectly to know their enemies, and to avoid them at the same time; which we cannot account for. Instinct, indeed, may teach the deer to fly from the lion; or the mouse to avoid the cat:—but what is the principle that teaches the dog to attack the dog-butcher wherever he sees him? In China, where the killing and dressing dogs is a trade, whenever one of these move out, all the dogs in the village, or the street, are sure to be after him.

I have seen, (says Dr. G—) more than one instance of the same kind among ourselves. I have seen a poor fellow, who made a practice of stealing and killing dogs for their skins, pursued hue and cry for three or four streets together, by all the bolder breed of dogs, while the weaker flew from his presence with affright.

How these animals could thus find out their enemy and pursue him, is unaccountable; but such is the fact; and it not only obtains in dogs, but in several other animals, though perhaps to a less degree.

The noise of the zebra is neither like that of a

horse or ass, but more resembling the confused barking of a mastiff dog. In the two, which I saw, there was a circumstance, that seem to have escaped naturalists, which is, that the skin hangs loose below the jaw, upon the neck, in a kind of dewlap, which takes away much from the general beauty.

The Squirrel is a beautiful little animal; which from the gentleness of its manners, deserves our protection. It is not hurtful. Its usual food is fruits, nuts, and acorns; it is cleanly, nimble, active, and industrious; its eyes are sparkling, and its physiognomy marked with meaning. It generally like the hare and rabbit, sits upon its hinder legs, and uses the fore paws as hands; these have five claws as they are called, and one of them is separated from the rest like a thumb. This animal seems to approach the nature of a bird, from its lightness and surprising agility. It seldom descends to the ground, except in case of storms, but jumps from one branch to another; feeds in spring, on the buds and young shoots, in summer, on the ripening fruits; and particularly the young coves of the pine tree. In autumn it has an extensive variety, the acorn, the filbert, the chesnut, and the wilding. This season of plenty, however, is not spent in idle enjoyment; the provident little animal gathers at that time its provisions for the winter, and cautiously foresees the season when the forest shall be stripped of its leaves and fruitage.

Its nest is generally formed among the large branches of a great tree, where they begin to fork off into small ones. After chusing the place where the timber begins to decay, and a hollow may easily be formed, the squirrel begins by making a kind of level between the forks; and then bringing moss, twigs, and dry leaves, it binds them together with great art, so as to resist the most violent storm. This is covered on all sides, and has but a single opening at top, which is just large enough to admit the little animal; and this opening is itself defended from the weather

by a kind of canopy that throws off the rain, though never so heavy. The nest thus formed with a very little opening above, is nevertheless, very commodious and roomy below : soft, well knit together, and every way convenient and warm. In this retreat the little animal brings forth its young, shelters itself from the heat of the sun, which it seems to fear, and from the storms and inclemency of the winter, which it is still less capable of supporting. Its provision of nuts and acorns is seldom in its nest, but in the hollows of the tree, laid up carefully together, and never touched but in cases of necessity. Thus one single tree serves for a retreat and a store-house, and without leaving it during the winter, the squirrel possesses all those enjoyments that its nature is capable of receiving.

The Marmot is almost as big as a hare, but is more corpulent than a cat, and has shorter legs. Its head pretty nearly resembles that of a hare, except that its ears are much shorter. It is clothed all over with very long hair, and a shorter fur below. These are of different colours, black and grey.

The length of the hair gives the body the appearance of greater corpulence than it really has, and at the same time shortens the feet so that its belly seems to touch the ground. Its tail is tufted and well furnished with hair, and it is carried in a straight direction with its body. It has five claws behind, and only four before. These it uses as the squirrel does, to carry its food to its mouth, and it usually sits upon its hinder parts, to feed in the manner of that little animal. It is readily taught to dance, to wield a cudgel, and to obey the voice of its master. Like the cat, it has an antipathy to the dog, and when it becomes familiar to the family, and is sure of being supported by his master, it attacks and bites even the largest mastiff. From its squat muscular make, it has great strength joined to great agility. However, it is in general a very inoffensive animal ; and, except its enmity to dogs, seems to live in friendship with

every creature, unless when provoked. As its legs are very short, and made somewhat like those of a bear, it is often seen sitting up, and even walking on its hind legs. Like all the hare kind, it runs much swifter up hill than down ; it climbs trees with great ease, and runs up the clefts of rocks, or the contiguous walls of houses with great facility.

Those arms which the Hedge-hog possess in miniature, the Porcupine has in an enlarged degree.

In the one, the spines are but an inch long ; in the other, a foot. The Porcupine is about two feet long, and fifteen inches high. It is covered with quills from ten to fourteen inches long, resembling the barrel of a goosequill in thickness ; but tapering and sharp at both ends. Each quill is thickest in the middle : and inserted into the animal's skin, in the same manner as feathers in birds. The biggest are often fifteen inches long, and a quarter of an inch in diameter, extremely sharp, and capable of inflicting a mortal wound. They are harder than common quills, and solid at the end which is not fixed in the skin. All these quills incline backwards, like the bristles of a hog ; but when the animal is irritated, rise and stand upright.

Such is the formation of this quadruped, in those parts in which it differs from most others. As to the rest of its figure, the muzzle bears some resemblance to that of a hare, but black ; the legs are very short and the feet have five toes, both before and behind, and these, as well as the belly, the head, and all other parts of the body, are covered with a sort of short hair, like prickles ; there being no part, except the ears and the sole of the foot that is free from them : the ears are thinly covered with very fine hair, and are in shape like those of mankind : the eyes are small like those of a hog, being only one third of an inch from one corner to the other. After the skin is taken off there appears a kind of paps on those parts of the body from whence the large

quills proceed; these are about the size of a small pea, each answering to as many holes as appear on the outward surface of the skin, and which are about half an inch deep, like as many hollow pipes, wherein the quills are fixed, as in so many sheaths.

This animal partakes much of the nature of the hedge-hog; having this formidable apparatus rather to defend itself, than annoy the enemy. Indeed many have supposed that it was capable of discharging at its foes, its quills. But, it is now well known that its quills remain fixed in the skin, and are then only shed, when the animal moults them, as birds do their feathers.

The Pangolin, a native of the torrid climates of the ancient continent is, of all animals, the best protected from external injury. It is three or four feet long, or taking in the tail, from six to eight. It has a small head, a very long nose, a short thick neck, a long body, legs very short, and a tail extraordinary long. It has no teeth, but is armed with five toes on each foot, with long white claws. But what it is chiefly distinguished by, is its scaly covering. These scales defend the animal on all parts, except the under part of the head and neck, under the shoulders, the breast, the belly, and the inner side of the legs; all which parts are covered with a smooth, soft skin, without hair. The scales of this extraordinary creature are of different sizes, and different forms, and stuck upon the body somewhat like the leaves of an artichoke. The largest are near the tail, which is covered with them like the rest of the body. These are above three inches broad, and about two inches long; thick in the middle, and sharp at the edges. They are extremely hard, like horn. They are convex on the outside, and a little concave on the inner, one edge sticks in the skin, while the other laps over that immediately behind it. Those that cover the tail are so hard, when the animal has acquired its full growth, as to turn a musquet-ball.

This lapped round the rest of the body, and being defended with shells even more cutting than any other art, the creature continues in perfect security. Its shells are so large, so thick, and so pointed, that they repel every animal of prey, they make a coat of armour that wounds while it resists, and at once protects and threatens. The most cruel beasts of the forest, the tiger, the panther, and hyæna, make vain attempts to force it. They roll it about, but all to no purpose ; the pangolin remains safe while its invader feels the reward of its rashness.

The Armadillo is chiefly an inhabitant of South America ; a harmless creature, incapable of offending any other, and furnished with a peculiar covering for its own defence.

This animal being covered like a tortoise, with a shell, or rather a number of shells, its other proportions are not easily discerned. It appears at first view a round mishapen mass, with a long head, and a very large tail sticking out at either end.

It is of different sizes, from a foot to three feet long, and covered with a shell, divided into several pieces, that lap over each other, like the plates in the tail of a lobster. This covers the head, the neck, the back, the sides, the rump, and the tail to the very point. The only parts to which it does not extend are the throat, the breast, and the belly, which are covered with a white soft skin. By this means the animal has a motion in its back, and the armour gives way to its necessary inflexions. These shells are differently coloured in different kinds. But most usually they are of a dirty grey. This colour in all arises from another peculiar circumstance in their conformation ; for the shell itself is covered with a softish skin, which is smooth and transparent.

Beasts may be considered as a numerous groupe, terminated on every side by some, that but in part deserve the name. On one quarter we see a tribe

covered with quills, or furnished with wings, that lift them among the inhabitants of the air, on another, we behold a diversity clothed with scales and shells, to rank with insects; and still on a third, we see them descending into the waters, to live among the mute tenants of that element. We now come to a numerous tribe, that seem to make approaches even to humanity, that bear an awkward resemblance of the human form, and discover the same faint efforts at intellectual sagacity.

Animals of the monkey class are furnished with hands instead of paws, their ears, eyes, eye-lids, lips, and breasts, are like those of mankind: their internal conformation also bears some distant likeness; and the whole offers a picture that may mortify the pride of such as make their persons the principal objects of their admirations.

These approaches, however, are gradual, and some bear the marks of our form, more strongly than others.

In the Ape-kind we see the whole external machine strongly impressed with the human likeness; these walk upright; want a tail, have fleshy posteriors, have calves to their legs, and feet nearly like ours.

In the Baboon-kind, we perceive a more distant approach; the beast mixing in every part of the animal's figure, these generally go upon all fours; but some, when upright, are as tall as a man: they have short tails, long snouts, and are possessed of brutal fierceness.

The Monkey-kind are removed a step further: these are much less; with tails as long as their bodies, and flattish faces.

Lastly, the Opossum-kind, seem to lose all resemblance of the human figure, except in having hands, their noses are lengthened out, and every part of

their bodies totally different from the human ; however, as they grasp their food, with one hand, which beasts cannot do, this single similitude gives them an air of sagacity, to which they have scarce any other pretensions.

The Baboon, is from three to four feet high, very strong built, with a thick body and limbs, and canine teeth, much longer than those of men. It walks more commonly upon all fours than upright, and its hands as well as its feet are armed with long, sharp claws, instead of the broad, round nails of the ape-kind.

At the Cape of Good Hope, they are under a sort of natural discipline, and go about whatever they undertake with surprising skill and regularity. When they set about robbing an orchard or vineyard, (for they are extremely fond of grapes, and apples) they go in large companies, and with pre-concerted deliberation ; part of them enter the enclosure, while one is set to watch. The rest stand without the fence, and form a line reaching all the way from their fellows within to the rendezvous without, which is generally in some craggy mountain. Every thing being thus disposed, the plunderers within the orchard throw the fruit to those that are without as fast as they can gather it ; or, if the wall or hedge be high, to those that sit on the top ; and these hand the plunder to those next them on the other side. Thus the fruit is pitched from one to another all along the line, till it is safely deposited at their head quarters. They catch it as readily as the most skilful tennis-player can a ball ; and while the business is going forward, a profound silence is observed. Their sentinel, during this whole time, continues upon the watch, and if he perceives any one coming, instantly sets up a loud cry, on which signal, the whole company scamper off. Nor yet are they willing to go empty handed ; for if they be plundering a bed of melons, for instance, they go off with one in their mouths, one in their hands, and one under their arm. If the pursuit is hot, they drop first that from under their arm, then that from their hand ;

and, if it be continued, they at last let fall that which they had kept in their mouths.

The Chimpanze is an animal found in Angola, nearly approaching to the human figure; but of a fierce disposition, and remarkably mischievous. In the year 1738, one of these creatures was brought over to England. It was about twenty months old. [The parent had it in her arms, when she was killed; she was five feet high.] It was of the female sex, naturally walked erect, was hairy on some part of the body and limbs, and of a strong, muscular make. It would eat any coarse food, but was very fond of tea, which it drank out of a cup, with milk and sugar, as we do. It slept in the manner of the human species, and its voice resembled the human, when people speak very hastily; but without any articulate sounds. The males of this species are very bold, and will fight a man, though he is armed. It is said they often assault and ravish the negro women, when they meet them in the woods.

There is another strange species of monkey found in the West Indies, of the size of a Fox. Its face is raised high, its eyes black and shining, and its ears small and round. His hairs are so nicely disposed all over the body, that he appears perfectly smooth: and they are much longer under the chin, so that they form a kind of beard there.

These are found in great numbers in the woods, and make a loud and frightful noise. But it is very common for one only to make a noise, and the rest to form a mute assembly round him.

Marcgrave says, "I have frequently seen great numbers of them, meeting about noon: at which time they formed a large circle, and one placing himself above the rest, began to make a loud noise. When he had sung thus by himself, for some time, the rest all remaining silent, he lifted up his hand, and they all instantly joined in a sort of chorus.

This intolerable yell continued, till the same monkey, who gave the signal for their beginning, lifted up his hand a second time. On this they were all silent again, and so finished the business of the assembly.

The Opossum, is about the size of a Cat, only more corpulent, and its legs more robust. It is of a kind of Chesnut colour, very bright and glossy. Its head is long, and terminates in a snout, somewhat like a Fox's. The tail is long, and much resembles that of a rat, which it twists about with a surprising facility. The legs being short, the body is carried at no great distance from the ground. On the belly of the female, a bag is formed by the skin being doubled. It is not very deep, the closest part being toward the upper part of the body, and the open part toward the lower. This is covered with fur, like the rest of the body, so that it is not very obvious to the sight.

It is a harmless, but likewise a defenceless animal : and the young of no creature, are produced so small and tender, in respect of the parent animal. Therefore that bag is extremely useful to them. They are cherished by the warmth of the parent's body, till toward noon : then they go abroad till at the first warning by the evening cold, they retire into their lodging again. Nor is this all the help which it affords. For as the tender young of the opossum are delicate morsels, they would be exposed to the rage of many animals, both by day and night. But the body of the parent is a safe and ready receptacle for them. By day she is as watchful over her brood as a hen over her chickens. She is alarmed at the slightest appearance of danger, and by a noise which they well understand, instantly calls them into her bag. At night she constantly takes them in, and consults for herself and them in a very uncommon manner. There are those among the devourers of her young, who will climb a tree after her. Therefore when she

has climbed, to secure herself and her young still farther, she twists her tail twice round some small bough, and then drops from it. There she hangs with her head downward : and whenever she pleases, she recovers the branch with her feet by a swing, and loosening her tail, walks about as usual.

To enable her thus to hang, there are spikes or hooks in the under side of the vertebre of the tail. Indeed, in the first three vertebre there are none ; for they would be of no use. But they are found in all the rest. They are placed just at the articulation of each joint, and in the middle from the sides. Nothing could be more advantageously contrived. For when the tail is twisted round a bough, these hooks easily sustain the weight. And there is no more labour of the muscles required, than just to bow or crook the tail.

Another animal of a very peculiar kind is an Ichneumon. It is of the weasel-kind, with a longer and narrower body than a cat, something approaching to the shape and colour of a badger. Its nose is black and sharp, like that of a ferret. Its colour is a yellowish grey. Its legs are short, and each of its feet has five toes. Its tail is very long ; its teeth and tongue much like those of a cat. It is a very cleanly animal, very brisk and nimble, and of great courage. It will engage a dog, and will destroy a cat, by three bites on the throat. But it is quite inoffensive to mankind, and is kept tame in Egypt, running about the house, destroying all vermin, and playing tricks, like spaniels.

When wild, he cannot overtake any nimble animal. But he makes this up by assiduity. His legs being short, he is not much seen ; but he has a way of concealing himself yet more, by crawling with his belly close to the ground, which he does all day long. But on the least noise (for his hearing is exceeding quick) he starts up erect on his hinder legs. If the noise is made by any reptile, bird, or small beast, he observes

whereabouts it is, places his nose directly in a line with it, and begins to move toward it. He is silent and slow, but constant in his approach; often stopping to hear or look forward, and knows exactly where the creature is: when he is got within about five feet, he stops. Nature, which has denied him speed, has given him strength to leap, beyond most other creatures. Having taken good aim, he springs from the place, and falls directly on his prey. Thus he deals with beasts and birds. But to serpents he gives chase, and to avoid their bite, always seizes them by the neck.

Gesner tells, that the *Ichneumon* is not only an enemy to serpents themselves, but to their eggs also: which he hunts after continually and destroys, though he does not feed upon them.—How mercifully has God given this animal in the countries where those terrible reptiles most abound! And which, without this provision, would be so over-run with them, as to be uninhabitable.

The Jackal is of the carnivorous kind. They hunt by scent and go in packs. They pursue with patience, rather than swiftness, and excite each other by a spirit of emulation.

It goes for current that the Jackal discovers the lion's prey; that each of these retains one of them, and having satisfied himself, lets his dependent feed on the offals of his repast.

But the truth is, there are great numbers of jackals in some woods, and when one of these sees a stag, or other large beast, which is not a beast of prey, he sets up his cry, which is like that of a hound and follows it. As he continues his cry, the other Jackals that are within hearing follow likewise. And could the creature outrun those that began the chase, there is a continual supply; so that it cannot escape. When they have run it down, they worry it at once, and it is devoured almost in an instant. After this the jackals disperse, till another cry invites them.

They hunt generally in the night, and in the parts of the East where they are most frequent, there never is a night but they are heard, in one part or other of the woods. The other beasts of prey understand the sound : and frequently profit by it. If a lion, tyger, or leopard happens to be near, he hears the cry, and stands upon the watch. These large animals are all very swift, but they are lazy, and never make long pursuits. If the creature pursued be far off, and runs another way, they never trouble themselves about it. But if it be near, or if it runs toward the place where the lion is, he will dart out upon it as it goes by. And the little animals that hunted it down must stand by, and be content with what their master leaves.

The Sable-mice, (which were first observed in Lapland, in 1697) are near as big as a small squirrel. Their skin is streaked and spotted with black and light brown. They have two teeth above, and two under, very sharp and pointed. Their feet are like a squirrel's. They are so fierce, that if a stick be held out to them, they will bite it, and hold so fast, that they may be swung about in the air. In their march they keep a direct line, generally from north-east to south-west. Innumerable thousands are in each troop, which is usually a square. They lie still by day, and march by night. The distance of the lines they go in, parallel to each other, is of some ells. Whatever they meet in their way, though it were a fire, a deep well, a torrent, lake, or morass, they avoid it not, but rush forward. By this means many thousands of them are destroyed. If they are met swimming over a lake, and are forced out of their course, they quickly return into it again. If they are met in woods or fields and stopt, they raise themselves on their hinder legs, like a dog, and make a kind of barking noise, leaping up as high as a man's knee, and defending their line as long as they can. If at last they are forced out of it, they creep into

holes, and set up a cry, sounding like *biab, biab*. If a house stands in their way, they never come into it, but stop there till they die. But they will eat their way through a stack of corn or hay. When they march through a meadow, they eat the roots of the grass : and if they encamp there by day, they utterly spoil it, and make it look just as if it had been burnt. They are exceeding fruitful ; but their breeding does not hinder their march. For some of them have been observed to carry one young in their mouth, and another upon their back. In winter they live under the snow, having their breathing-holes, as hares and other creatures have.

I would mention only two creatures more, very extraordinary, and yet but little known.

The Glutton is frequent in the forests of Germany. It is rarely seen twice of the same figure. It is of the weasel-kind, and is in its middle state, about the size of a turn-spit dog. Its body is long, its legs short. Its colour is brown, with a reddish tinge ; but its breast and belly are white. The tail is long and bushy ; the head small and sharp at the nose. The teeth are exceeding sharp, and the claws sharper than almost in any creature.

This is the most hungry animal in the world, but is ill provided for catching its prey. Most creatures can out-run it, and itself can scarce run away from any thing. But what he wants in swiftness, he has in climbing, which he performs to admiration : its sharp claws enabling it to run up a tree as fast as on the ground. Its usual place is some large and spreading oak, chose both for safety and for catching its prey. He squats all day on some large branch ; and if nothing offers below, he preys in the night on whatever creatures he can find on the tree above. Many birds roost on such trees, which he climbs softly to, and devours. But his favourite food is larger animals. He will lie many days on a slanting bough ; and

when any which he likes comes underneath, he drops down upon them. Hares and rabbits seldom escape him ; but he chooses rather a goat, or any creature of that size. When one of these comes under the tree, he creeps from bough to bough, till he comes just over it, and then drops down upon it. He always contrives to fasten on the neck. In an instant he fixes both his teeth and claws, and lies across the neck, near the shoulders. Here he is secure; and while the poor creature runs with all its speed, he is feeding on its flesh. At length it drops, and he continues eating in the same ravenous manner, till from a mere skeleton, his back becomes round, and his sides swelled out like a ton. Still he continues to eat, till he can eat no longer. He too drops down, and lies panting for breath. He resembles a dead carcase, swelled and ready to burst with lying in the sun: and being unable to move for a long time, is frequently destroyed, and sometimes perishes without an enemy.

The God of nature seems to have formed the Sloth, to represent to us in a strong light, that odious and despicable vice, from which it takes its name. Its body is short, its head small, and it has scarce any tail. Its fur is long, thick, and of a greyish green, so that when seen on the bough of a tree, it appears only like an excrescence or a cluster of moss. It is about the size of a cat, but the legs are short, as is the neck: and its long and thick covering, renders it so shapeless, that it seems only an irregular lump of living matter. Its little and remarkably ugly head stands close between the shoulders. The face has much of the monkey aspect. Its small and heavy eyes, are always half shut, and it has no appearance at all of any ears. Its feet are flat and very narrow, but armed with sharp claws, for laying hold on the bark of a tree, by striking deep into it.

He rarely changes his place; and never, but when compelled by absolute necessity. As upon the ground

it would be a prey to every other animal, so its constant residence is on a tree. Here it is safe from all animals, but those who climb these trees for the birds that roost on them. The leaves and tender part of the tree are its food, and serve it for drink as well as meat. It never moves to another branch, till it has devoured all the nourishment upon that where it is stationed : nor from one tree to another, till the first is wholly withered and wasted.

It is observable, the Sloth always ascends to the top of a tree, only baiting as he goes, before he begins his devastations. And this is doubtless from the instinctive guidance of nature. For was it to begin eating upward, when it had devoured all, it would have to climb down from the top of a dead tree, and would be half starved in its journey. But this is not all. The havoc which one sloth makes on the largest tree is easily seen. For he eats not only the leaves, but all the buds and bark, leaving only a dead branch : so that unless the same thing might happen by accident this would betray the creature. It does so happen; and trees then put on the same form, as when they are left by the sloth. But they always die at the top first, and so gradually downward. This animal therefore, wonderfully taught, begins its havoc at the top. As it feeds, the tree decays ; but its decay is in the course of nature. The decay spreads downward ; and when he has eaten the last of his provision, he is near the ground, and has only to walk away to another tree. But if it is at any distance, his motion is so slow, that he grows quite lean in the expedition.

As the Sloth brings forth her young in the hollow of a tree, so is she led by the same wonderful instinct to conduct them to the topmost branches, as soon as they crawl out. When she is big with young, she climbs some old, hollow tree ; and having fixed on a convenient spot for her young, she climbs to the very highest bough, and there feeds faster than usual. When she is full, she descends with unaccustomed

haste, and brings forth one, two, or three young ones. It is well she is full fed ; for she is to support these with her milk, till they can crawl out, without having any supply herself. She is round and fleshy when she retires for this purpose, but a mere skeleton when she comes out. She crawls as well as she can, to the part where she left off feeding, and her young follow her. Nor will she touch any thing in the way, however both her hunger and laziness may prompt her to it.

It is the most timorous of all creatures. And with reason : for it can neither fight nor fly. While it is journeying on the ground, the tread of a human foot shakes the earth enough to put it into terrors. It trembles : the head is turned about every way, and the mouth is open to cry like a young kitten.

Insignificant as this creature is, there is a special Providence in the formation and care of it. Not designed for walking, its claws enable it to climb, and then to hold fast in its station. Helpless as it is, the universal Provider has assigned it a place of safety, where it finds plenty of food ; and as it cannot easily seek for drink, it has no need of any. To render it the less obnoxious to pursuit, its colour secures it even from view : and its amazing instinct of feeding from the top to the bottom, proves a designing and directing Hand.

Before I proceed to some general reflections upon beasts, I beg leave to take notice of one circumstance, relating to several species of them, which is very strange, though very common.—The horns of many animals fall off every year, and new ones come in their place. Our deer drop them in March, and the new horns are full grown by the July following. We may justly rank this, among the most wonderful phenomena of nature, which yields nothing analogous to the growth of such hard solid bodies, of so great a bulk, in so short a time. Many idle opinions have been maintained, concerning the cause of their falling

off. The truth seems to be this : they are a sort of vegetables, growing on animals, as the nails and hair on man, and feathers on birds. And there is some analogy between the growth of them, and that of branches and leaves on trees. Trees commonly drop their leaves in autumn, because the nourishing juice flows into them no longer. And at certain periods, these parts of the animal drop off, because the blood and juices cease to flow in them. At this time, the hollow part at the root of the horn grows hard, and the pores through which the juices passed, grows up. And as no more nourishment can then be carried to the horn, it decays and falls off. It is probable this stoppage of the pores happens, as soon as the horns are at their full growth. But they are so fixed to the head, that it takes a long time for them to loosen and fall. Whereas in leaves, their stalks are so tender, that when the juice ceases to flow, they presently wither and fall.

The analogy between the falling off of deers horns and the falling of leaves and ripe fruit from the tree, will receive light from observing the process of nature in the latter case. If the stalk from which a ripe orange has fallen, be compared with that part of a deer's forehead, from which a horn is just fallen, it will plainly appear that nature has operated by the same laws in both. The young horns, while yet soft, are full of blood-vessels ; and if cut off, especially near the head, bleed violently. By these vessels they are supplied with nourishment for their growth. But these dry up, when there is no farther occasion for them. And hence it is, that no ill symptoms attend the falling off of these parts, when full grown.

So far we may give a probable account:—But who can account for this, that if a stag be castrated, while he is so young as not to have horns, he will never have any : and if castrated afterward, while his horns are on, he will never cast them ?

10. It remains only to add a few reflections. And first, what admirable wisdom is displayed, in the motion of various animals, suited to their various occasions ! In some, their motion is swift ; in others, slow ; and both diversified a thousand ways.

And first, for swift or slow motion. This is exactly proportioned to the occasion of each animal. Reptiles, whose food, habitation, and nests lie in the next clod, plant, tree, or hole, or which can bear long hunger, need neither legs, nor wings, but their vermicular motion answers all their purposes.

Beasts, whose occasions require a larger room, have accordingly a swifter motion : and this in various degrees, answerable to their range for food, and the enemies they are to escape from.

But as for birds who are to traverse vast tracts of land and water, for their food, habitation, breeding their young, and for places of retreat and security, from various inconveniences : they are endued with the faculty of flying ; and that swiftly or slowly, a long or short time, according to their occasions. In all this, the wisdom of God appears, ordering all things well.

Again. How admirable in the motion of all creatures, is the neat, geometrical performance of it ! The most accurate mathematician cannot prescribe a nicer motion than that they perform, to the legs and wings of those that fly or walk, or to the bodies of those that creep. Neither can the body be more completely poised, for the motion it is to have in every creature. From the largest elephant to the smallest mite, the body is exactly balanced. The head is not too heavy, nor too light for the rest of the body, nor the rest of the body for it. The bowels are not too loose, or so placed as to swag, overbalance, or overset the body : but well braced, and accurately distributed to maintain the equipoise of it. The motive parts also are admirably well fixed, in respect to the centre of gravity, placed in the very point which best serves to support and convey the body. Every leg bears its

true share of the weight. And the wings are so exactly placed, that even in the fluid medium, the air, the body is as truly balanced, as we could have balanced it with the nicest scales.

Yet again. What an admirable provision is made for the motion of some creatures, by temporary parts ! Frogs, for instance, have tails in their tadpole state, which fall off when their legs are grown out. The water-newt also, when young, has four fins, two on a side, to poise and keep the body upright. But as soon as the legs are fully grown, these presently drop off.

Secondly, the bore of the gullet in all creatures, is answerable to their occasions. In a fox, which feeds on bones, (as in all ossivorous beasts) it is very large. But in a squirrel it is exceeding small, lest he should disgorge his meat in his descending leaps : and so in rats and mice, which often run along a wall with their heads downward.

Thirdly, In all animals the strength and size of their stomach are proportioned to their food. Those whose food is more tender and nutritive, have it smaller, thinner, and weaker. Whereas it is large and strong in those whose food is less nutritive, and whose bodies require large supplies.

All carnivorous beasts have the smallest stomachs, as flesh goes the farthest. Those that feed on fruits and roots have them of a middle size. Sheep and oxen, which feed on grass, have the greatest. Yet the horse, hare, and rabbit, though granivorous, have comparatively small ones. For a horse is made for labour, and both this and the hare for quick and continued motion : for which the most easy respiration and so the freest motion of the diaphragm is requisite. But this could not be, did the stomach lie big and cumbersome upon it, as it does in sheep and oxen.

Another very remarkable circumstance is, that those animals which have teeth on both jaws, have but one stomach ; whereas most of those which have

no upper-teeth, or no teeth at all, have three stomachs. For the meat which is first chewed, is easily digested ; but that which is swallowed whole, requires a stronger concoctive power.

Fourthly, All the parts of the same animal are adapted one to the other. So for instance, the length of the neck is always proportioned to that of the legs. Only the elephant has a short neck : for the weight of his head and teeth, would to a long neck, have been insupportable. But then he is provided with a trunk, which abundantly supplies the defect. In other beasts and birds, the neck is always commensurate to the legs : so that they which have long legs, have long necks, and they that have short legs, short ones ; as may be observed in lizards of all kinds and the king of them, the crocodile. And creatures that have no legs, as they want no necks, so they have none, as fishes. This equality between the length of the neck and legs, is peculiarly seen in beasts that feed on grass. Their legs and necks are very near equal. Very near, I say, because the neck must necessarily have some advantage ; for it cannot hang perpendicular, but must incline a little.

Moreover, as these creatures must hold their heads down, for a considerable time together, which would be very laborious and painful for the muscles, therefore on each side of the neck, nature has placed a thick and strong ligament, capable of stretching and shrinking again as need requires : this, which is vulgarly called white leather, extends from the head (to which, and the next vertebre of the neck it is fastened at that end) to the middle vertebre of the back, to which it is knit at the other. And by the assistance of this, they are able to hold the head in that posture all day long.

Fifthly, The parts of all animals are exactly fitted to their manner of living. A notable instance of this

is in the Swine. His natural food being chiefly the roots of plants, he is provided with a long and strong snout ; long, that he may thrust it to a convenient depth in the ground, without offence to his eyes ; strong and conveniently formed, for rooting and turning up the ground. And besides, he has an extremely quick scent, for finding out such roots as are fit for him. Hence in Italy, the usual way of finding truffles, or subterraneous mushrooms, is by tying a cord to the hind-leg of a pig, and driving him before them into their pastures. They then observe where he stops and begins to root : and digging there they are sure to find a truffle. So in pastures where there are earth-nuts, though the roots are deep in the ground, and the leaves are quite gone, the swine will find them by their scent, and root only in the places where they grow.

Another instance of like nature we have in the porpus (anciently written porc-pesce, that is, Swine-fish) which resembles the hog, both in the strength of his snout and in the manner of getting his food. For the stomach of one of these when dissected, was found full of sand-eels, which lie deep in the sand, and cannot be gotten, but by rooting and digging there.

That very action, for which we look upon swine as unclean creatures, namely, wallowing in the mire, is designed by nature for a good end ; not only to cool their bodies (which fair water would do as well) but also to suffocate and destroy fleas, lice, and other insects, which are troublesome and hurtful to them. For the same reason, poultry and divers other birds bask themselves in the dust, in hot summer weather.

The variety of shape and colour observable in beasts, prevents any two from being exactly alike, as much as the human features distinguish mankind one from another. Wherefore then was this variety bestowed upon brutes ? Are they at all sensible of

such diversity? Are they the more happy, or more useful to one another for it? No. This variety then is doubtless intended for the sake of man, to prevent confusion, and decide and ascertain his property.

CHAP. II.

OF BIRDS.

1. Some general Remarks :	6. Stomach and Bladder :
2. Of their Motion :	7. Generation.
3. Brain :	8. Of some particular Sorts of
4. Organs of Sense :	Birds.
5. Lungs :	9. Reflections.

1. **N**O part of nature is destitute of inhabitants. The woods, the waters, the depths of the earth, have their respective tenants ; while the yielding air, and those tracts where man never can ascend, are also passed through by multitudes of the most beautiful beings of the creation.

Every order of animals is fitted for its situation in life : but none more apparently than birds. Though they fall below beasts in the scale of nature, yet they hold the next rank, and far surpass fishes and insects, both in the structure of their bodies and in their sagacity.

The body of man presents the greatest variety : beasts, less perfectly formed, discover their defects in the simplicity of their conformation : the mechanism of birds is yet less complex : fishes are furnished with fewer organs still ; while insects, more imperfect than all, fill up the chasm between animal and vegetable nature. Of man, the most perfect animal, there are but three or four species ; the kinds of beasts are more numerous ; birds are more various still ; fishes yet more ; but insects afford an immense variety.

In all birds, except nocturnal ones, the head is smaller, and bears less proportion to the body than in beasts, that it may the more readily divide the air in flying. Their eyes also are more flat and depressed, and a circle of small plates of bone, placed scale-wise under the outer coat of the organ, encompasses the pupil on each side to strengthen and defend it from injuries. Besides this, birds have a kind of skin called the nictitating membrane, with which, like a veil, they can at pleasure cover their eyes, though their eyelids continue open. This membrane serves also to wipe, cleanse, and probably to moisten its surface. The eyes, though they outwardly appear but small, yet each almost equals the brain; whereas in man the brain is more than twenty times larger than the eye.

Hence it follows that the sense of seeing in birds is infinitely superior to that of other animals. Indeed this piercing sight seems necessary to the creature's support and safety. Were it not so, from the rapidity of the bird's motion, it would be apt to strike against every object in its way, and it could scarcely find subsistence unless it could discern its food from above with astonishing sagacity. A hawk, for instance, perceives a lark at a distance, which neither men nor dogs could spy; and a kite, from an almost imperceptible height darts down on its prey with the most unerring aim.

Granivorous birds, or such as live upon vegetables, have their intestines differently formed from those of the rapacious kind. Their gullet dilates just above the breast-bone, and forms itself into a pouch or bag called the crop. This is replete with salival glands, which moisten and soften the food it contains. After the dry food of the bird has been macerated, it passes into the belly, where, instead of a soft moist stomach, as in the rapacious kinds, it is ground between two pair of muscles, commonly called the gizzard, covered on the inside with a strong ridgy coat. These coats rubbing against each other, are capable of attenuating the hardest substances; their action being often compar-

ed to that of the grinding teeth in man and other animals.

Thus the organs of digestion are in a manner reversed in birds. Beasts grind their food with their teeth, and then it passes into the stomach, where it is softened and digested. On the contrary, birds of this sort first soften it in the crop, and then it is ground and comminuted in the stomach or gizzard. Birds are all careful to pick sand, gravel, and other hard substances, not to grind their food, as has been supposed, but to prevent the too violent action of the coats of the stomach against each other.

To birds, the return of spring is the beginning of pleasure. Those vital spirits which seemed locked up during winter, then begin to expand; vegetables and insects supply abundance of food; and the bird having more than a sufficiency for its own subsistence, is impelled to transfuse life as well as to maintain it. Those warblings which had been hushed during the colder seasons, now begin to animate the fields; every grove and bush resounds with the challenge of anger, or the call of allurements. The delightful concert of the grove, which is so much admired by man, is no way studied for his amusement: it is the call of the male to the female; his efforts to sooth her during the time of incubation, or a challenge between two males for the affections of some common favourite.

It is by this call that birds begin to pair at the approach of spring, and provide for the support of a future progeny. The loudest notes are usually from the male; the hen expresses her consent in a short interrupted twittering. Their compact holds with unbroken faith: most birds live with inviolable fidelity together, and when one dies the other is always seen to share the same fate soon after. We must look for it in our fields and in our forests, where nature continues in unadulterated simplicity; where the number of males is generally equal to that of females: but the male of all wild birds is as happy in the young brood as the

female. They both seem, at this season, transported with pleasure; every action testifies their tender solicitude.

But previous to laying, the work of nestling becomes the common care, and this is performed with no small degree of assiduity. It has been asserted that birds of one kind always make their nests in the same manner, and of the same materials; but the truth is, they vary this as the materials, places, or climates differ. The red-breast, in some parts of England, makes its nest with oak leaves, where they are in plenty, and in other parts with moss and hair. Some birds that with us make a very warm nest, are less solicitous in the warm climates. In general, however, every species of birds has a peculiar architecture of its own, and this adapted to the number of eggs, the temperature of the climate, or the heat of the animal's body. Where the eggs are numerous, the nest is warm, that the animal's heat may be equally diffused to them all. Thus the wren, and all the small birds, make their nests very warm, for having many eggs, it is requisite to distribute warmth to them all; on the contrary, the plover, that has but two eggs, the eagle, and the crow, are not so solicitous in this respect as their bodies are capable of being applied to the small number upon which they sit.

Nothing can exceed the patience of birds while hatching; neither hunger nor danger can drive them from the nest. They are fat upon beginning to sit, yet before incubation is over, are usually wasted to skin and bone. Indeed ravens and crows, while the females are sitting, take care to provide them with food in abundance. But it is different with most of the smaller kinds; during the whole time the male sits near his mate upon some tree, and soothes her by his singing; and often when she is tired takes her place, and patiently continues on the nest till she returns.

So great is the power of instinct in these animals, that they continue almost passive under its influence.

Yet, at the same time, the hen that has all this seeming ingenuity, in other respects, is without the least glimmerings of common sense; she mistakes a piece of chalk for an egg, and sets upon it in the same manner: she is insensible of any increase or diminution in the number of those she lays: she does not distinguish between her own and those of another species; and when the birth appears of never so different a bird, will cherish it for her own.

As the principle which acts in these animals cannot be termed reason, so when we call it instinct, we mean something we have no knowledge of. It appears to me the immediate direction of Providence; and such an operation of the Supreme Being as that which determines all the portions of matter to their proper centres.

While the young are yet unfledged, the old one takes care to provide them with a regular supply; when the family is fully plumed, and capable of avoiding danger by flight, they are then led forth when the weather is fine, and taught the paternal art of providing for their subsistence. They are led to the places where their food lies; they are shewn the method of discovering or carrying it away; and then led back to the nest for a day or two longer. At length, when they are qualified to shift for themselves, the old one takes them abroad, and leading them to the accustomed places, forsakes them for the last time, and all connection is at an end.

Birds in general, though they have so much to fear from man and each other, are seldom scared from their usual haunts. The greatest number remain contented where they have been bred. The rook, if undisturbed, never desires to leave his native grove; the black-bird still frequents its accustomed hedge; and the red-breast, though seemingly mild, claims a certain district, from whence he seldom moves, but drives out every one of the same species from thence without pity. They are excited to migrations by no other motives but those of fear, climate, or hunger. It is

from one of these motives that birds of passage, every year, forsake us for some time, and make their regular returns. The cause of their retreat is, either scarcity of food, or the want of an asylum from man, during the time of courtship and bringing up their young. Thus the starling, at Sweden, at the approach of winter, finding subsistence no longer, descends into Germany; and the hen chaffinches of the same country are seen to fly every year through Holland, to pass their winter in a milder climate. Others prepare for longer journeys. Thus the quails, in spring, forsake the heats of Africa for the milder sun of Europe; and when they have passed the summer with us, steer their flight to enjoy, in Egypt, the temperate air. This with them seems a preconcerted undertaking. They unite together in some open place, for some days before their departure, and, by an odd kind of chattering, seem to debate on the method to proceed; then they all take flight together, and often in such numbers, that to mariners at sea, they seem like a cloud upon the horizon. The strongest, and by far the greatest number, make good their intention; but many there are, who grow weary in the way, and drop down into the sea, and sometimes upon the decks of ships.

Of the vast quantity of water-fowl that frequent our shores, few are known to breed here. The cause that urges them to leave us seems to be, not merely the want of food, but the desire of a secure retreat. Our country is too populous for birds so shy, as the greatest number of these are. When great part of our island was an uncultivated tract of woods and marshes, many species of birds, which now migrate, remained with us the whole year. The great Heron and the Crane, that have now forsaken this country, in former times bred familiarly in our marshes. Their nests, like those of most cloven-footed water-fowl, were built on the ground, and exposed to every invader; but as rural œconomy increased, these animals were more and

more disturbed. Once they had little to fear, as the surrounding marsh defended them from all the carnivorous surrounding quadrupeds, and their own strength from birds of prey; but by a long series of alarms, they have, at length, been obliged to seek, during the summer, some lonely habitation, at a safe distance from every destroyer.

Of the numerous tribes of the Duck-kind, we know of no more than five that breed here. The rest contribute to form that amazing multitude of water-fowl which annually repair to the dreary lakes and deserts of Lapland, from the more southern countries of Europe. In those solitary retreats, they perform the duties of incubation and nutrition in full security. There are few of this kind that may not be traced to the northern deserts, to countries of lakes, rivers, swamps, and mountains, covered with thick and gloomy forests. In those regions, from the thickness of the forests, the ground remains moist and penetrable during the summer season; the woodcock, the snipe, and other slender-billed birds, can there feed at ease, while the web-footed birds find more than sufficient food from the number of insects which swarm to an incredible degree. The days there are long, and the beautiful nights afford them every opportunity of collecting so minute a food.

2. Birds have feathers which they expand in order to fly, the fine branches of which lie so close together, that little air can insinuate itself between them. Now when the column of air on which a body rests is specifically heavier than the body, it remains suspended in the air; if it be lighter, the body sinks. Hence the larger space a body circumscribes, the more easily does the air sustain it: consequently the same bird which sinks when the wings are closed, is sustained when they are expanded. To this also the motion of the wings contribute: (as a body while moving swiftly will swim in water, which immediately sinks if that

motion ceases.) And so do the feathers with which their bodies are clothed, which increase their bulk, but not their weight in the same proportion.

The parts of birds chiefly concerned in flying, are the wings and the tail. By the first, the bird sustains and wafts himself along: by the second he is enabled to keep his body steady and upright, particularly in ascending and descending. It is by the largeness and strength of the pectoral muscles that they are qualified for flying. In men these are scarce a seventeenth part of the muscles of the body. In birds they considerably outweigh all the other muscles together. And this circumstance alone, the want of suitable muscles, makes all human attempts to fly void and vain.

Nevertheless the art of flying has been seriously attempted by many, in various ages, particularly in the time of our famous Friar Bacon, who lived about 500 years since, and whom his excellent works shew to have been a rare chymist, an excellent mathematician, a knowing mechanic, and a most accomplished experimental philosopher. Yet even he believed the art of flying possible, and says, he himself knew how to make an engine, in which a man sitting might be able to convey himself through the air like a bird. Nay, he affirms, that there was then another person who had actually tried it with success.

In flying, the bird first bends his legs and leaps from the ground; then opens the joint of his wings so as to make a right line, perpendicular to the sides of his body. Being now raised and strongly vibrating his wings, the air re-acts as much as it is acted upon, and so protrudes his whole body; but in recovering his wing for fresh strokes, it has a great resistance to overcome. To elude this, the bony part of the wing, into which the feathers are inserted, moves sideways with its sharp end foremost, and the feathers follow it like a flag.

All birds have near their tail a little bag, which contains oil to moisten their feathers. Geese have two glands for the secretion of this; other birds only one.

In this are divers little cells ending in two or three large ones, lying under the nipple of the oil-bag. This nipple is perforated, and being prest by the bird's bill, emits its oil.

In all birds that fly much, the wings are placed in the very best manner to balance their bodies in the air, and to give as swift a progression as they are severally capable of. Otherwise they would reel and fly unsteadily, as we see they do if we destroy the equipoise by cutting one of their wings.

And what nicety may we observe, in a part no more considerable, than the vanes of the flag-feathers of the wing!—1. The edges of the exterior or narrow vanes bend downward, but the interior, wider vanes upward. By this means they catch hold and lie close to each other, when the wing is spread, that not one feather may miss its full force and impulse upon the air. 2. Equal nicety is observed in the very sloping the tips of the flag-feathers; the interior vanes are neatly sloped away to a point toward the outward part of the wing. The exterior (at least in many birds) are sloped toward the body, and in the middle of the wing, the vanes being equal, are but little sloped; so that the wing, whether open or shut, is as neatly sloped as if constantly trimmed with a pair of scissars.

The vane consists not of one continued membrane, because if once broken, it would not easily be repaired; but of many laminæ, which are thin, stiff, and something resembling a thin quill. Toward the shaft of the feather (especially in the flag-feathers of the wing) these laminæ are broad and of a semicircular form, which serves for strength and for shutting them close together, when impulses are made on the air. Toward the outer part of the vane, they grow slender and taper, on their under side they are thin and smooth, but their upper outer edge is parted into two hairy edges.

As curiously made are the feathers in the wing, and no less curiously placed, exactly according to their several lengths and strength; and these again are lined,

faced, and guarded with covers and secondary feathers, to keep the air from passing through and so eluding the impulse.

How admirably wrought are the bones of the wing ! very strong, but light withal ; the joints, which open, shut, and move every way, as occasion is, and the various muscles, all suited to the motions which they minister to.

Next to the parts for flight, let us view the legs and feet which minister to their other motions, both made light for their easier passage through the air, and the latter, some with membranes for swimming, some without, for steady going, for perching, for catching, and holding their prey, or for hanging by the heels to gather their food : the legs, all curved, for their easy perching or roosting, as also to help them upon their wings in taking their flight. In some they are long, for wading and searching the waters, in others, if need be, remarkably short. And how wisely are they placed ! In all somewhat out of the centre of the body's gravity ; but in such as swim, more than in others, for the better rowing their bodies, as also to help them in diving.

Geese and Ducks, their bodies being made for swimming, have their wings too placed out of the centre of gravity, nearer the head ; but the extending the neck and head in flight, balances the body upon the wings, which is another excellent use (beside searching for food) of the long necks of these birds.

But in the Heron, whose head and long neck (although tucked up in flight) overbalances the hinder part of the body ; the long legs are extended both to counterpoise the body and to supply what is wanting in the tail.

It has been supposed that the flying of birds is analogous to the rowing of vessels ; but it is a motion of quite another kind. Oars are struck toward the stern ; whereas birds do not vibrate their wings toward the tail, but waft them downward. Nor does the tail cut

the air (as the rudder does the water) at right angles, but horizontally. It likewise keeps the same situation which way soever the bird turns.

It is not therefore by the tail that most birds turn to the right hand or the left, but by the wings. They turn to the right by beating the air with the left wing alone toward the tail: to the left, by beating it with the right wing. Thus Pigeons* changing their course toward the left, labour with the right wing, scarce stirring the other.

Birds with long necks have another way of altering their course, by only inclining their head and neck this or that way.

Birds rarely fly up or down perpendicularly, but rather in a crooked line. In ascending directly, the natural and artificial tendency would counteract each other. In descending directly, both would concur, and endanger too précipitate a motion.

Only the Hawk stoops directly to seize its prey: whereas other birds in descending retard the motion by keeping their wings expanded, and at the same time stretching out their feet and legs.

There is no flying animal but has feet as well as wings, because there is no food or at least not food sufficient for them, to be had always in the air: but if there were, yet such birds could take no rest; for having no feet, they could not perch upon trees, and if they alighted on the ground they could not raise themselves again: which birds that have short feet can

* It is a remarkable use which is made of pigeons in the Eastern countries. They are trained up in Turkey and Persia to carry expresses; being first used to short flights, afterwards to longer, till at length they will return from the farthest part of the kingdom. Yea, if they are brought hood-winked twenty or thirty miles, nay, sixty or a hundred, they will find their way in a very little time to the place where they were bred. Every bashaw has a basket of these pigeons bred at the seraglio; one of which he dispatches thither on any emergent occasion, with letters braced under her wings. This proves a more speedy method, as well as safer, than any other. For one of these birds will carry a letter from Babylon to Aleppo, which is thirty days journey, in forty-eight hours.

hardly do. Beside, they would want means of breeding, having no way to lay their eggs, to sit, hatch, or brood their young.

Before we conclude this head, it may be observed, that all the parts of birds are fitted for the use of flying. First, as the muscles of the wings are peculiarly strong, so the under side of them is made concave, and the upper convex, that they may be the more easily lifted up, and the more strongly strike the air. Then the trunk of their body somewhat resembles the hull of a ship; the head the prow, which is generally small, that it may the more readily cut the air, and make way for the body. Add to this, that the bodies of birds are small in comparison of beasts, that they may be more easily supported by the air: and they are not only small, but of a broad figure, that they may be buoyed up the better. They are also hollow and light, yea, their very bones are light. For even those of the legs and wings have ample cavities: by this means also they become rigid and stiff, it being demonstrable that a hollow body is more stiff and inflexible than a solid one of equal substance. The shafts also of the feathers are either empty or filled with a light and spongy matter; and their webs consist of two rows of contiguous filaments furnished all along with hooks on each side, whereby catching hold of one another they stick fast together.

As to their tails, although it is true as was observed, that all birds whose tails are pointed and end in a right line, turn themselves by their wings and not their tails, yet in those that have forked tails it is otherwise. Thus it is manifest to sight, that the forked-tailed Kite, by turning her train sideways, raising one horn, and depressing the other, turns her whole body. And doubtless the tail has the same use in swallows, who have all forked tails, and make more sudden turns in the air than any other bird.

To lighten birds still farther, they have large membranes extending to the bottom of their bellies, into which the air is received, where, by the heat of the body it is expanded into twice or thrice the dimensions of the external air; and this they can either compress by the muscles of the abdomen, or expire more or less, in order to their descending swifter or slower, in what degree they please.

3. As to the brain of birds, whereas in men the cortical part of the brain is outermost, in birds it is innermost, and the membrane that covers the upper ventricle is medullary. The ventricles likewise are situated above, near the upper part of the skull.

Perhaps before we proceed, it may be well to premise one general observation, that the structure of birds is in many respects different from those both of men and beasts, having several parts which these want, and wanting others which they have. Besides, there are great variations in the contrivance of parts which are common to both, all wisely adapted to their different conditions and manner of life.

Parts peculiar to birds are, 1. The bill.—2. The membrane to draw over the eyes.—3. Feathers and wings. The parts wanting in birds are, 1. Teeth and lips.—2. The bladder, which they do not need, as they drink no more than just to moisten their food. Variations in the parts of birds from those of men and beasts are, 1. In the ear, which is of a very peculiar make.—2. In the division of the aorta.—3. In the spinal marrow, which is divided into two in the middle of the back.—4. In the bones, which are all hollow.—5. In the heart, which has a fleshy valve at the mouth of the vena cava.—6. In the lungs, which are strongly joined to the back, for the greater convenience of flight.—7. In the stomach; birds have two or more, to supply the want of chewing.—8. In the legs and

feet.—9. In their tails.—10. In their pectoral muscles, which are the strongest of all; whereas in man, the crural muscles are the strongest.—11. In the brain, as was before observed.—12. In the bronchia, which extends to the very bottom of the abdomen, so as to contain a large quantity of air.—13. In the ovaries, which in birds are single, and fastened on their back.

4. The ears of birds differ much from those both of men and beasts. There is almost a direct passage from ear to ear, so that if the drum be pricked in either ear, water poured in at one ear will run out at the other; and what is still more remarkable, they have a small winding passage that opens into a large cavity, running betwixt two skulls, and passes all round the head: the upper of these skulls is supported by many hundreds of small, thread-like pillars, which have another use also, to break their sound, and hinder its making a confused echo.

This passage between the two skulls is much larger in singing-birds than in others. So that a person who has been shewn this may hereby know them from all others.

The other organs of sense are nearly the same in birds as in other animals. Only there is a difference in the organ of smell: the nostrils lie on each side of the beak, in the inner part whereof, beside the tube which reaches to the lungs there are little tubes continued from the membranes and substance of the brain, and these seem to be the organ of smell. Only two nerves pass through the os cribrosum to the beak, lest if there were more perforations, as in other animals, too much air might flow into the brain.

The bill of birds is peculiarly remarkable. In the first place, it is neatly shaped for piercing the air. In the next it is hard and horny, to supply the want of teeth, and also in some measure, of a hand. Its hooked form is of great use to rapacious birds, in

catching and holding their prey ; and to others, in climbing, and in taking and comminuting their food.* Its extraordinary length and slenderness is of use to some, to search for their food in moorish places : † as its length and breadth is to others, to hunt and search in muddy places. ‡ The contrary form, a thick, short, and sharp-edged bill is as useful to all other birds, who must husk the grain they swallow. But it would be endless to reckon up all the shapes and commodious mechanism of all : the sharpness and strength of those that have occasion to perforate woods and shells, § the slenderness and neatness of such as pick up small insects : the cross form of such as break up fruits ; || the compressed** form of others,

* Parrots have their bills nicely adapted to these services, being hooked, for climbing and reaching what they want, and the lower jaw so exactly fitted to the hook of the upper that it will break the food, as other creatures do with their teeth.

† As to Woodcocks and Snipes, who hunt for worms in moorish ground, and likewise suck the unctuous humour out of the earth. So also the bills of Curlews, and other Sea-fowl, are very long, to enable them to hunt for worms, &c. in the sands.

‡ Ducks, Geese, and divers other species of birds, have bills both long and broad, whereby they are enabled to quaffer in the water or mud, till they find their food.

§ The green woodspite, and all woodpeckers have strong and sharp bills, curiously made for digging wood. An even ridge runs along to the top of the green woodpecker's bill, as if an artist had designed it at once for strength and neatness.

Woodpeckers have also a tongue, ending in a sharp, bony rib, dented on each side, which they can at pleasure shoot out to a great length, and thrust into the holes, clefts and crannies of trees. They strike them likewise into ant-hills, and fetch out the ants and their eggs. Moreover they have short, but strong legs, and their toes stand, two forward, two backward ; a disposition which is particularly convenient for the climbing of trees. In this they are likewise assisted by the uncommon stiffness of the feathers of their tails, and by their bending downward, whereby they are fitted to serve them as props to lean on.

|| The cross-bill, whose bill is thick and strong, with the tips crossing each other, readily breaks open fir-cones and other fruits, to come at and feed on the kernels. And undoubtedly the crossing of the bill was designed for this very service.

** The sea-pye has a long, sharp, narrow bill, compressed sideways, and every way adapted to the raising limpets from the rocks, which are its chief, if not only, food.

with many other curious forms, all suited to the occasions of the several species.

In the flat-billed birds, as ducks, there are three pair of nerves, which come down between the eyes in the upper bill, whereby they are enabled to smell and find out their food in the mire or water. The like have been observed in several round-billed birds, but so small as to be scarce discernible. Only in the rook they are discernible enough: and it is remarkable that these, more than any other round-billed birds, grope for their meat in cow-dung, and the like.

5. Of their lungs it is observable, that they are not only larger in proportion than those of beasts, but they admit the air, both above and beneath, by which means they become far lighter.

A duck is furnished with a peculiar structure of vessels, which enables it to live some time under water. Yet she cannot live without air. One that was put into the air-pump, and the air exhausted, seemed to bear it better for a few moments than any other fowl. But in less than two minutes her head fell down, and she appeared dying, till revived by letting in the air.

A young callow duck being tried in the same manner, was near death in less than two minutes. It is observable both of them swelled extremely, on pumping out the air. It not being intended that water-fowl should live in an exceeding rarified air, but only continue under water, they are qualified for this, but not at all for the other.

Yet that ducks can live almost any where, we may learn from the blind ducks of the Zerchintzer lake in Carniola, a territory of Austria. This communicates with another lake under ground in the mountain Savor-nick, and fills or empties itself according to the ful-

ness or emptiness of that. The waters of the upper lake, when it empties, run off by large holes in the bottom. The ducks which are very plentiful in the water, are often carried down with it into the subterraneous lake. In this many of them undoubtedly perish; yet some remain alive. But they lose their sight and their feathers: and at the next filling of the upper lake, both they and vast numbers of fish are thrown up with the water. They make a strange appearance in their naked state; and for want of sight are easily caught. In about a fortnight they recover their sight and their feathers, and are then as big as common wild-ducks. At their first coming up, their stomachs are full of small fishes, and something resembling weeds. It seems therefore, they were not quite blind, when in their dark habitation, but could see by that small quantity of light, to search for and find their food.

Nor is it in this lake only that these ducks are found. They are frequently thrown up, after great rains, at a hole in a mountain, near the town of Laon, in the Isle of France. The water then gushing out with great violence, brings these blind and bald creatures with it. And their frequency and cheapness, from the vast quantities which are thrown out, make them esteemed no variety.

The bodies of duckers or loons are admirably fitted for diving: being covered with a thick plumage, and the surface of it so smooth, that the water cannot penetrate it. Hereby their bodies are defended from the cold, the water being kept at a distance; and are so poised, that by a light impulse, they easily ascend in it. Again, their feet are situate in the hindmost part of their body, so that shooting them backward and striking the water upwards, they plunge themselves down with great ease, and move forward therein. Their legs also are made flat and broad, and their feet cloven into toes, with appendant membranes on

each side. By this configuration they easily cut the water, and are drawn forward, to take their stroke backward : and by this, their feet being moved to the right or left, serve them as a rudder to turn under water. How they rise above water is not determined : whether by their natural lightness, or by striking against the bottom, in the manner of a leap, or by some peculiar motion of the legs. That they dive to the bottom is undeniable. For in the stomachs, both of the greater and lesser kind, we find much grass and other weeds ; and in the lesser kind, little else. Yet both prey upon fish ; and their bills are straight and sharp, for the easier striking their prey.

It is likewise remarkable, that whereas in other animals the lungs are loose and have much play, in all birds they adhere to the thorax, and have little play. This is a good provision for their steady flight. Also they want the diaphragm, and instead thereof have divers large bladders, made of thin transparent membranes, with pretty large holes, out of one into the other. These membranes serve for braces to the viscera, as well as to contain air. Toward the upper part, each lobe of the lungs is perforated in two places, with large perforations ; whereof one is toward the outer, the other toward the inner part of the lobe. Through these perforations the air has a passage into the fore-mentioned bladders ; so that by blowing into the windpipe, the lungs are raised, and the whole belly blown up. This doubtless is a means to make them more or less buoyant, as they take in more or less air : and so answers the design of the air-bladder in fishes.

In general we may observe, whatever is peculiar in the wings, bills, and every other part of birds, on a close inspection will be found exactly suited to their wants. They are a set of implements nicely proportioned to their manner of life. To instance in a few,

sparrows and most small birds, are supported by the little grains they find up and down. They have no effort to make, to obtain their food, or break it in pieces, and therefore have a small bill, as well as short necks and legs, which are sufficient for their purposes. But the woodcock, snipe, curlew, and many other birds, seek their food deep in the earth or slime. Therefore they are provided with a long neck and bill, and with these they dig and search and want for nothing. The woodpecker, who lives in a quite different manner, is as differently formed. His bill is very long, solid, and strong : his tongue is sharp and extremely long ; beside which, it is armed with little points, and covered with glue toward the extremity. He has short legs, two talons before, two behind, and all very crooked. All this equipage suits his manner of living. His food is worms or insects, that live in the heart of branches of trees, or under the bark of old wood ; frequently they are sunk very deep, under the bark of large billets. The woodpecker has hooked claws, to grasp these branches ; and a strong and pointed bill, to find out by darting it up and down, what parts of them are rotten. When he has found out these, he with his bill, shatters the bark and wood. He then sends forth a loud whistling cry, into the cavity, to alarm the insects and put them in motion. Next he darts in his tongue, and by the small points which arise out of it, and the glue that covers it, draws out whatever lodged there.

The Heron, on the contrary, mounts aloft. His legs and thighs are very long, and bare of feathers. He has a great length of neck, and an enormous bill, very sharp and jagged at the end. What reason can be assigned for a figure, which at first sight seems so extravagant ? He feeds on frogs and small shell-fish, as well as other fish, which he finds in fens, or bogs, or near the shores of rivers. He wants no feathers on his thighs, to walk through water and slime ; but he needs very long legs, to run in the water, along the

shores, whither the fishes resort for their food. A long neck and bill qualify him for pursuing and seizing his prey at some distance : and the jaggs of his bill enable him to hold the fish, which would otherwise slide away. In fine, his large wings, which seem incommodious to a bird of so small a body, are absolutely needful for his making so great movements in the air and conveying such burdens to his nest, which is frequently two or three leagues distant from the place where he fishes.

The imperfections therefore which we imagine we discover in this (as in many other animals) in reality belong only to our own understanding; and all our censures of the works of nature, are in truth, only so many indications of our own ignorance.

6. The Stomach (especially of granivorous birds), is of a peculiar structure. First, there is a glandulous receptacle, wherein the grains are kept for some time. They are then received into another stomach, consisting of two muscles, and a callous membrane. One of these moves obliquely downward, and the other upward. Hereby the shell of the grain is broke, and the meal expressed and mixed with proper juices. The aliments thus prepared, fall into the bottom of the stomach, where they are purged again from the refuse : to which end that part is a little raised, that the corn may not pass out too soon. There is also a partition, which divides what is already digested from the rest.

As birds have no bladder, in the room of urine, a whitish excrement is discharged from the kidneys into the rectum.

7. The generation of birds is not well known in the ovary, placed between the liver and the backbone, a great number of yolks are contained ; one of which when impregnated, passes through the oviduct into the womb, where it receives the white and

the shell, and remains till it comes to its full size. The parent then broods over it, till the young being gradually formed, perfected, and quickened, bursts the shell.

Under the shell of an egg lies the common membrane, adhering closely to it, except at the bigger end, where a little space is left between them. This membrane contains two whites, each enclosed in its own membrane. In the middle of the inner white is the yolk, enclosed likewise in a separate cover. The outer white is oval, the inner round, (as is the yolk) and of a more viscid substance.

At each end is a chalasa, a white, dense body consisting of three little globules, like grains of hail, (so the word signifies) all joined together. These serve both to knit the several membranes together, and to keep the liquors in their proper places and position.

About the middle of the small end of the yolk, is a little yellowish bladder, like a vetch, called the cicatricula, or eye of the egg. This contains a humour, in and out of which the young bird is generated. The white serves it for food, till it becomes big: then the yolk, and likewise after it is hatched. For even then a good part of the yolk is lodged in its belly, as in a store-house, and being conveyed thence by the intestinal duct into the bowels, serves it instead of milk.

An egg, improperly so called, is that, of the whole whereof the animal is formed. Such are the eggs of flies. Proper eggs, when excluded need no external nutriment. Of proper eggs, some are perfect, that is, have all the parts above described, while in the ovary or womb: some imperfect, which have them not, till after they are excluded, as those of fishes, which assume a white in the water.

An egg not impregnated by the male, will never breed young, but always putrify. One impregnated contains the rudiments of the bird, even before incubation. By the microscope we see the plain carina or spine of it swimming in the middle of the cicatricula, consisting of fine white threads, which incubation gradually perfects.

The air-bag is very small in a new laid egg, but becomes larger, when the egg is kept. The yolk is specifically heavier than the white. Hence its smaller end is always uppermost in all positions of the egg.

After incubation, the air-bag gradually extends, till near the hatching, it takes up a third of the egg. By incubation the white becomes thinner and more turbid, especially near the air-bag where it is first consumed. Then it lessens towards the sharp end of the egg, till nothing is left, but a white, chalky substance. The white of an impregnated egg is as sweet all the time of incubation as that of a new laid-egg. They are only unimpregnated eggs, vulgarly called wind-eggs, which putrify and stink.

The yolk also remains fresh and uncorrupted all the time of the incubation. It is depressed in the middle, as the chick grows, and is soon brought into a form, not much unlike that of a horse shoe, in the middle of which the chick lies.

Not long before the chick is hatched, the whole yolk is taken into the abdomen.

The eye or tread, in which the chick lies, is soon enlarged by incubation, and rises to the upper part of the egg. The heart and umbilical vessels, are some of the first parts, which we are able to distinguish.

The embryo is seen at first like a small worm. Then its carina or spine appears, with the large prominences that afterwards shew themselves to be the brain and eyes. The other bowels seem hanging from the spine. Then the chasm of the mouth is discovered. The extremities sprout out. The bowels are gradually covered with the teguments. At last the beak, nails, and feathers are seen. When all its parts are formed, the chick is always found lying on its side, with its neck bent forward, the head covered with the upper wing, and the beak placed between the thighs.

The birds which nourish their young, have commonly very few. On the contrary, those whose young feed themselves, when they first see the day, have sometimes eighteen or twenty at a brood. This prudence could only spring from Him, who regulates all things to the best advantage. Were those who provide for their young to have so numerous a brood, both the parents would be slaves, and yet the young but ill accommodated. Whereas the mother, who only marches at their head, without nourishing them, can conduct twenty as well as four.

But when they first make their appearance, what care do the parents take, till their young can subsist without them? Of those that feed their young, the linnet and the nightingale then labour like the rest. Sometimes one parent goes in quest of provisions, sometimes the other, and sometimes both. They are up before the sun. And the food they have procured, they distribute with great equality, giving each a portion in its turn, before ever they feed one bird twice.

And this tenderness for their offspring, is so strong, as even to change their natural disposition. Follow the hen when she is the parent of a family, and she is no longer the same creature. She is no longer ra-

venous and insatiable. If she finds but a grain of corn or a crum of bread, she never touches it herself but calls her troop by a note they well understand, and divides it among them. She is no longer timorous, but at the head of her young, will spring even at the stoutest dog.

When the turkey-hen appears at the head of her young, she sometimes utters a mournful cry, and they immediately run under bushes, furz or whatever presents itself. She looks upward and repeats her cry: which is occasioned by her seeing a bird of prey, though so distant, that he appears unto us, only as a dark point under the clouds. But he no sooner disappears, than she utters another cry, which revives all her brood. They run to her, flutter their wings, and shew all the tokens of joy. Now, who apprizes her of an enemy, that never yet committed any act of hostility in the country? And how is she able to discover him, when at so great a distance? How are her family instructed to understand her different cries, and regulate their behaviour accordingly? What wonders are these which are daily obvious to our view, though we treat them with inattention?

An amazing degree of natural instinct, or understanding, God has imparted to birds of passage. They fly in troops, often in the form of a wedge, with the point foremost. They steer their course through unknown regions, without either guide or compass. And they are peculiarly accommodated for their flight by the structure of their parts.

In the act of migration, it is highly remarkable, 1. That they know, (as the scripture speaks) their appointed times, when to come and when to go. Appointed by whom? Surely by the great Creator, who has imprinted on their nature an inclination, at such a time to fly from a place that would obstruct their generation, or not afford food for them and their

young, and betake themselves to another place, which will afford all that is wanting.

It is highly remarkable, 2. That they know whither to go, and which way to steer their course! That they should be directed yearly to the same place, perhaps to a little island, as the Basse in Edinburgh Frith. How come land-birds to venture over a vast ocean, of which they can see no end? And how do they steer their course aright to their several quarters, which before the compass was invented, man himself was not able to do? They could not possibly see them at that distance. Or if they could, what should teach or persuade them that that land is more proper for their purpose than this? That Britain, for instance, should afford them better accommodations than Egypt, than the Canaries, than Spain, or any other of the intermediate places?

But it has been commonly supposed that several birds are of this number, because they disappear in winter, which really are not; cuckoos for instance, and swallows: for neither of these ever cross the seas. Cuckoos lodge all the winter in hollow trees, or other warm and convenient cavities. And swallows have been found in vast quantities, clung together in a lump, like swarms of bees, but utterly cold and senseless, even in ponds that have been cleaned out, hanging under the water.

I know not how we can doubt of this fact, that swallows have been found in winter, under water, clung together, attested by men of unquestionable veracity. And yet others affirm, that they have seen flights of swallows crossing the sea in autumn. The truth seems to be this. There are some species of swallows, which seek a warmer climate at the approach of winter, while others remain here in a temporary death, like the flies on which they feed.

They have in Virginia, a martin like ours, only larger, which builds in the same manner. Col. Bacon observed for several years, that they constantly came

thither upon the 10th of March. Two of them always appeared a day or two before, hovering in the air, then they went away, and speedily returned, with the whole flock.

The following seems to be a very rational account of most of those that are really birds of passage.

When by the approach of our winter their food fails, birds of passage are taught by instinct to seek it elsewhere. Want of food seems to be the chief reason of their migration. The length of their wings enables them to catch the flying insects, with which the air is stored during the warm months. And most summer birds of passage, feed on the wing upon such insects, as are seen no more when winter comes. If it be considered, how much of the globe still remains unknown, it is no wonder we are not yet acquainted with the places to which they retire. Probably they lie nearly in the same latitude in the southern hemisphere, as those from whence they depart.

As swallows cannot bear so much cold, as some other birds of passage, they are constrained to visit us somewhat later, and to depart somewhat sooner. Some stay a month after them. Probably many of them perform their long journies chiefly in the night. Lying on the deck of a sloop on the north-side of Cuba, I and the company with me heard three nights successively, flights of rice-birds (their notes being plainly distinguishable) passing over our heads northerly, which is their direct way from the southern continent of America, from whence they go yearly when the rice begins to ripen, and after growing fat, return back.

There are also winter birds of passage, which arrive here in autumn and go away in spring, namely the fieldfare, redwing, woodcock, and snipe. But the two latter sometimes spend the whole year here. Whereas the two former, constantly at the

approach of summer, retire to more northern climates where they breed, and remain till at the return of winter, they return to us again.

The winter food of these birds being berries and haws, which are far more plentiful here than in more northern regions, this is one reason of their coming over: but the principal is, the severity of the weather in those climates, which nature teaches them to exchange, for such as are more temperate. But why do they depart from us in spring: This still remains among the secrets of nature.

Beside these summer and winter birds, there are others which come periodically to certain places, for the sake of some sort of food, which their own country is destitute of. These quickly depart, and are seen no more till that time twelvemonth. Such are the rice-bird and blue-wing of Carolina.

But above half a century passed from the time of cultivating rice and wheat in Carolina, and Virginia, before these foreign birds made their appearance there. The wheat birds now come annually to Virginia, when the wheat ripens, and have come every year, since their first appearance, in numerous flights.

The species of birds already known, amount to about eight hundred. Linnæus divides them into six classes; namely, into birds of the rapacious kinds, birds of the pie-kind, birds of the poultry kind, birds of the sparrow-kind, birds of the duck-kind, and birds of the crane-kind. The four first comprehend the kinds of land birds, the two last, those that belong to the water.

In beginning with the feathered tribe, the Ostrich seems to unite the class of beasts and of birds in itself. While it has the general outlines and properties of a bird, it retains many of the marks of a beast. In appearance it resembles the camel, and is almost as tall; it is covered with a plumage that resembles hair much more than feathers, and its internal parts bear as near a similitude to those of the beast,

as of the bird creation. It may be considered, therefore, as an animal made to fill up that chasm in nature which separates one class of beings from another. It is usually seven feet high from the top of the head to the ground. The external eye is like that of a man, the upper eye lid being adorned with eye-lashes which are longer than those on the lid below.

They inhabit the most solitary deserts, where there are few vegetables, and where the rain never comes. The Arabians assert, that the ostrich never drinks; and the place of its habitation confirms the assertion. In these regions, ostriches are seen in large flocks, which to the distant spectator appear like a regiment of cavalry. The ostrich is of all other animals the most voracious. It will devour leather, hair, grass, iron, stones, or any thing that is given. But those substances, which the coats of the stomach cannot soften, pass whole; so that hair, stones, and iron, are excluded in the form in which they were devoured.

In their native deserts, however, they live chiefly upon vegetables, where they lead an inoffensive and social life; the male, as Thevenot assures us, assorting with the female with connubial fidelity. They lay generally from forty to fifty eggs. It has been commonly reported, that the female deposits them in the sand, leaves them to be hatched by the heat of the climate, and then permits the young to shift for themselves. Very little, however, of this is true: no bird has a stronger affection for her young: none watches her eggs with greater assiduity. Indeed in those hot climates, there is no necessity for the continual incubation of the female; but though the female forsakes her eggs by day, she carefully broods over them by night. Then they sit on their eggs like other birds, and the male and female take this office by turns. Nor do they forsake their young after they are excluded the shell. On the contrary, the young ones are not even able to walk for several

days after they are hatched. During this time, the old ones are very assiduous in supplying them with grass, and very careful to defend them from danger : nay, they encounter every danger in their defence.

All land-birds of the rapacious kind, are furnished with a large head, and strong crooked beak, notched at the end, for the purpose of tearing their prey. They have strong short legs, and sharp crooked talons for the purpose of seizing it. Their bodies are formed for war, being fibrous and muscular ; and their wings for swiftness of flight, being well feathered and expansive. The sight of such as prey by day is astonishingly quick : and such as ravage by night, have their sight so fitted as to see objects in darkness. Thus formed for war, they lead a life of solitude, they inhabit by choice, the most lonely places. They make their nests in the clefts of rocks, and in the highest and most inaccessible trees of the forest. Whenever they appear in the cultivated plain it is only for the purposes of depredation, and they spread terror wherever they approach : all the variety of music, which but a moment before enlivened the grove, at their approach is at an end : lesser birds seek for safety, either by concealment or flight, and some are even driven to take protection with man, to avoid their less merciful pursuers.

It would indeed be fatal to all the smaller race of birds, if as they are weaker than all, they were also pursued by all : but it is contrived wisely, that every order of carnivorous birds seek only for such as are of a size approaching their own. The eagle flies at the bustard or the pheasant, the sparrow-hawk at the thrush and the linnet. And nature has provided that each species should make war only on such as are furnished with adequate means of escape. The smallest birds avoid their pursuers by the extreme agility, rather than the swiftness of their flight ; for every order would soon be at an end, if the eagle, to its swiftness of wing, added the versatility of the sparrow.

Another circumstance which tends to render the tyranny of these animals more supportable, is, that they are less fruitful than other birds. Those of the larger kind seldom produce above four eggs, often but two; those of the smaller kinds, never above six or seven. Likewise the carnivorous kinds only breed annually, and of consequence their fecundity is small.

8. The largest of birds is the Cuntur of Peru. The body is as big as that of a sheep. Its wings extended are fifteen or sixteen feet from point to point. It is never seen in forests, because it would not have room to fly, but frequents the sea-shore and the banks of rivers. Nature, to allay their fierceness, has denied them the talons given to eagles, though they are of the eagle-kind. However, their beak is strong enough to tear off the hide, and rip up the bowels of an ox.

What a blessing is it to mankind, that there are but few (just enough to keep up the species) of this monster in the feathered creation! And into what can we resolve this, but the wise and overruling care of an adorable Providence?

In beasts the smallest animals are noxious, and loathsome; the smallest of birds are the most beautiful, innocent, and sportive. Of all those that flutter in the garden, or paint the landscape, the humming-bird is the most delightful to look upon, and the most inoffensive.

Of this there are six or seven varieties, from the size of a small wren, down to that of an humble bee. An European could never have supposed a bird existing so very small, and yet completely furnished with a bill, feathers, wings, and intestines, exactly resembling those of the largest kind. A bird not so big as the end of one's little finger, would probably be supposed but a creature of imagination, were it not seen in infinite numbers, and as frequent as

butterflies in a summer's day, sporting in the fields of America, from flower to flower.

The smallest is about the size of a hazle-nut. The feathers on its wings and tail are black ; but those on its body, and under its wings, are of a greenish brown, with a fine red cast or gloss, which no silk or velvet can imitate. It has a small crest on its head, green at the bottom, and as it were gilded at the top, and which sparkles in the sun like a little star in the middle of its forehead. The bill is black, straight, slender, and of the length of a small pin.

As soon as the sun is risen, the humming-birds, of different kinds, are seen fluttering about the flowers, without ever lighting upon them. Their wings are in such rapid motion that it is impossible to discern their colours, except by their glittering. They are never still, but continually in motion, visiting flower after flower : they are furnished with a forked tongue, that enters the cup of the flower, and extracts its nectared tribute. Upon this alone they subsist. The rapid motion of their wings bring out an humming sound from whence they have their names.

The nests of these birds are not less curious than the rest : they are suspended in the air, at the points of twigs of an orange, a pomegranate, or a citron-tree. The female is the architect, while the male goes in quest of materials, such as cotton, fine moss, and the fibres of vegetables. Of these materials a nest is composed, of about the size of a hen's egg cut in two, admirably contrived, and warmly lined with cotton. They lay two eggs at a time, about the size of small peas, and as white as snow, with here and there a yellow speck. The male and female sit upon the nest by turns ; but the female takes to herself the greatest share. She seldom quits the nest, except a few minutes in the morning and evening when the dew is upon the flowers. The time of incubation continues twelve days ; at the end of which the young ones appear, much about the size of a blue-bottle fly.

Father Labat's companion, in the mission to America, found the nest of a humming-bird, and took it in, at a time when the young ones were about fifteen or twenty days old; he placed them in a cage at his chamber window; but he was soon surprised to see the old ones, that came and fed their brood regularly every hour in the day. By these means they themselves soon grew so tame, that they seldom quitted the chamber; but without any constraint, came to live with their young ones.

All four have frequently come to perch upon their master's hand, chirruping as if they had been at liberty. He fed them with a fine clear paste, made of wine, biscuit, and sugar. They thrust their tongues into this paste, till they were satisfied, and then fluttered and chirruped about the room. I never beheld any thing more agreeable, continues he, than this lovely little family, that had taken possession of my companion's chamber, and that flew out and in just as they thought proper; but were ever attentive to the voice of their master when he called them. In this manner they lived with him for above six months. but, at a time when he expected to see a new colony, he unfortunately forgot to tie up their cage to the ceiling at night, to preserve them from the rats, and he found they were devoured in the morning.

Even Vultures are in Egypt of singular service. There are great flocks of them in the neighbourhood of Grand Cairo, which no person is permitted to destroy. The service they render the inhabitants, is the devouring the carrion and filth of that great city, which might otherwise corrupt and putrify the air. They are commonly seen in company with the wild dogs of the country, tearing a carcase very deliberately together. This odd association produces no quarrels; the beasts and birds live amicably, and nothing but harmony subsists between them.

The wonder is still the greater, as both are extremely rapacious, and both lean and bony to a very

great degree, having no great plenty even of the wretched food on which they subsist.

In America wherever the hunters go, who pursue beasts for their skins, these birds pursue them. They still keep hovering at a little distance ; and when they see the beast flead and abandoned, they call out to each other, pour down upon the carcase, and in an instant, pick its bones as clean as if they had been scraped by a knife.

Rooks keep together in pairs ; and when the offices of courtship are over, prepare for making their nests and laying. The old inhabitants of the place are already provided ; the nest which served them for years before, with a little dressing will serve again ; the difficulty of nestling lies only upon the young ones who have no rest. And not only the materials are wanting, but also the place in which to fix it. Every part of a tree will not do for this purpose, as some branches may not be sufficiently forked ; others may not be sufficiently strong ; and others may be too much exposed to the rockings of the wind.

The male and female upon this occasion are, for some days, seen examining all the trees of the grove very attentively, and when they have fixed upon a branch fit for that purpose, they continue to sit upon and observe it very sedulously for two or three days longer.

The place being determined, they begin to gather the materials ; such as sticks and fibrous roots, which they regularly dispose in the most substantial manner. But here a new and unexpected obstacle arises, it often happens that the young couple have made choice of a place too near the mansion of an older pair, who do not chuse to be incommoded by neighbours. A quarrel therefore instantly ensues, in which the old ones are always victorious.

The young couple thus expelled, are obliged again to go through the fatigues of examining, and chuse

ing; and having taken care to keep their due distance, the nest begins again. But they grow weary of bringing materials from distant places; and perceive that sticks may be provided nearer home. Away they go, therefore, to pilfer as fast as they can; and wherever they see a nest unguarded, they rob it of the choicest sticks of which it is composed. But these thefts never go unpunished. Eight or ten rooks come, and setting upon the new nest of the young couple at once, tear it in pieces in a moment.

At length, therefore, the young pair find the necessity of going more honestly to work. While one flies to fetch the materials, the other sits upon the tree to guard it; and thus in the space of three or four days, with a skirmish now and then between, the pair have fitted up a commodious nest, composed of sticks without, and fibrous roots and long grass within. From the instant the female begins to lay, all hostilities are at an end; not one of the whole grove that a little before treated her so rudely, will now molest her; so that she brings forth her brood with patient tranquillity. Such is the severity with which even native rooks are treated by each other; but if a foreign rook should attempt to make himself a denizen of their society, the whole grove would at once be up in arms against him, and expel him without mercy.

In all its habits the Magpie discovers a degree of instinct unusual to other birds. Its nest is not less remarkable for the manner in which it is composed, than for the place it is built in: either in the middle of some hawthorn bush, or on the top of some high tree.

It is always difficult of access; for the tree or bush pitched upon, usually grows in some thick hedge-row fenced by brambles at the root.

When the place is chosen as inaccessible as possible to men, the next care is to fence the nest above from various enemies.

The kite, the crow, and the sparrow-hawk, are to be guarded against ; as their nests have been sometimes plundered by the magpie, so it may be, they will take an opportunity to retaliate. To prevent this, the magpie's nest is built with surprising labour and ingenuity.

The body of the nest is composed of haw-thorn branches ; the thorns sticking outward, but well united together by their mutual insertion. It is lined with fibrous roots, wool, and long grass, and nicely plastered round with mud and clay. The body of the nest being thus made firm and commodious, the next work is to make the canopy which is to defend it above.

This is composed of the sharpest thorns, so wove together, as to deny all entrance except at the door which is just large enough to permit egress and regress to the owners. In this fortress the male and female hatch and bring up their brood with security, sheltered from all attacks but those of the climbing school boy, who often finds his torn and bloody hands too dear a price for the eggs or the young ones.

As the Wood-pecker is obliged to make holes in trees to procure food, so is it also to make cavities still larger to form its nest and to lay in. This is performed as usual with the bill. He chuses for this purpose, trees that are decayed, or wood that is soft, like beech, elm, and poplar. In these, with very little trouble, it can make holes as exactly round as a mathematician could with compasses. One of these holes the bird generally chuses for its own use, to nestle, and bring up its young in, but as they are easily made, it is delicate in its choice, and often makes twenty before one gives entire satisfaction:

In our climate, wood-peckers are contented with a wainscoat habitation for their young, but in Guinea and Brazil, they take a very different method. A traveller who walks into the forests of these countries among the first strange objects, is struck with the

multitude of birds nest hanging at the extremity of almost every branch. Many other kinds of birds build in this manner, but the chief of them are of the wood-pecker kind.

In cultivated countries a great part of the caution of the feathered tribe, is to hide their nests from the invasion of man. But in the depths of those remote and solitary forests, the little bird having nothing to apprehend from man, is careless how much the nest is exposed to general notice : satisfied if it be out of the reach of those rapacious creatures that live by robbery, and surprise. If the monkey or the snake can be guarded against, the bird has no other enemies to fear : for this purpose, its nest is built upon the depending points of the most outward branches of a tall tree. On one of those immense trees, is seen the most various assemblage of creatures that can be imagined. The top is inhabited by monkeys of some particular tribe, that drive off all others : lower down twine about the trunk numbers of snakes, waiting till some unwary animal comes within their reach, and at the edges of the tree hang these artificial nests, inhabited by birds of the most delightful plumage.

The nests are usually formed in this manner : when the time of incubation approaches, they fly beautifully about, in quest of a kind of moss, called by the English, old man's beard. It is a fibrous substance, not unlike hair, which bears being moulded into any form. This the little wood-pecker first glues by some viscous substance, to the extreme branch of a tree ; then building downward, a nest is formed, that descends like a pouch, from the point of the branch : the hole to enter at, is on the side ; and all the interior parts are lined with the finer parts of the same substance, which compose the whole.

Such is the general contrivance of these hanging nests ; made by some other birds, with still superior art. A little bird in the Phillippine islands, makes

its nest in such a manner that there is no opening but from the bottom. At the bottom the bird enters, and goes up through a funnel, like a chimney, till it comes to the real door of the nest, which lies on one side.

Some birds glue their nests to the leaf of the banana tree, which makes two sides of their little habitation; while the other two are artificially composed by their own industry. But these, and all of the kind, are built with the same precautions, to guard their young against the depredations of monkeys and serpents. The nest hangs there, before the spoilers, a tempting object, which they can only gaze upon, while the bird goes in and out without danger and molestation.

The Bird of Paradise appears to be as large as a pigeon, though in reality not much greater than a thrush. The tail is about six inches long, the wings are large, compared with the bird's other dimensions. The head, the throat and the neck are of a pale gold colour. The base of the bill is surrounded by black feathers, as also the side of the head and throat, as soft as velvet, and changeable like those on the neck of a mallard. The hinder part of the head is of a shining green, mixed with gold. The body and wings are chiefly covered with brown, purple, and gold feathers. The uppermost part of the tail-feathers are of a pale yellow, and those under them white and longer than the former; for which reason the hinder part of the tail appears to be all white. But what chiefly excites curiosity, are, two long naked feathers, which spring from the upper part of the rump above the tail, and are usually about three feet long. These are bearded only at the beginning and the end, the whole shaft, for above two feet nine inches, being of a deep black, the feathered extremity of a changeable colour.

This bird is a native of the Molucca islands. There, in the delightful and spicy woods, do these beautiful

creatures fly in large flocks, so that the groves which produce the richest spices, produce the finest birds also. They are called by some, the swallows of Ternate from their rapid flight, and from their being continually upon the wing, in pursuit of insects, their usual prey.

The American Mock-bird does not vie with the feathered inhabitants of that country in the beauty of his plumage. It is a plain bird about the size of a thrush, of a white and grey colour, and a reddish bill. It is possessed not only of its own natural notes, which are musical and solemn, but can assume the tone of every other animal in the wood, from the wolf to the raven. It seems even to sport itself in leading them astray. It will at one time allure the lesser birds with the call of their males, and terrify them when they come near with the screams of the eagle. There is no bird in the forest, but it can mimic; and there is none that it has not at times deceived by its call. But it is surest to please, when it is most itself.

At those times it frequents the houses of the American planters, and sitting all night on the chimney-top, pours forth the sweetest and the most various notes of any bird whatever.

The Crane, is above three feet from the tip of the beak to the tail, and four feet from the head to the toe. It is a tall, slender bird, with a long neck and long legs. The top of the head is covered with black bristles, and the back of it is bald and red, which sufficiently distinguishes this bird from the stork, to which it is very nearly allied in size and figure.

Cranes were formerly known in this island, and held in great estimation for the delicacy of their flesh: there was even a penalty upon such as destroyed their eggs; but at present, they never go so far out of their way.

Cultivation and populousness go hand in hand; and though our fields may offer them a greater plenty, yet they find the venture greater than the enjoyment, and we are better off by their absence than their company.

The Crane spends the autumn in Europe; then flies off to some more southern climate, returns to Europe in spring, crosses up to the north in summer, visits those lakes that are never dry, and then comes down again to Italy in autumn.

In these journies it is amazing to conceive the heights to which they ascend. Their note is the loudest of all birds, and that is often heard in the clouds, when the bird itself is entirely unseen. But though unseen themselves, they have the distinct vision of every object below. They govern and direct their flight by their cries, and exhort each other to proceed or descend when a fit opportunity offers.

Their loud clangorous sound is, when near, almost deafening: however it is particularly serviceable to the animal itself, either during its migrations or stay: by it the flock is encouraged in their journies; and if while they are feeding, which is performed in profound silence, they are invaded on any side, the bird that first perceives it sounds the alarm, and all are speedily upon the wing.

The Stork also is a bird of passage, and goes away toward winter to the southern countries. It has a very long beak, and long red legs. It feeds on serpents, frogs, and insects. As it seeks for these in watry places, nature has provided it with long legs. And as it flies to the nest with its prey, its bill is strong and jagged to hold fast what it has taken: she likewise digs with her bill into the earth for snakes or adders, which she carries to her young. Most of her feathers are white. She lays but four eggs, and sits for thirty days.

But what renders this bird most remarkable is, its

steady love to its parents. It never forsakes them when they are old, but tenderly feeds and defends them as long as they live.

The following adventure of a tame stork some years ago in the University of Tübingen, seems to shew a degree of understanding which one would scarce expect in the brute-creation. This bird lived quietly in the court-yard, till Count Victor Gravenitz, then a student there, shot at a stork's nest adjacent to the college, and probably wounded the stork then in it. This happened in autumn, when foreign storks usually leave Germany. The next spring a stork was observed on the roof of the college, which after a time came down to the upper gallery, the next day something lower, and at last, by degrees quite into the court. The tame stork went to meet him with a soft cheerful note, when the other fell upon him with the utmost fury. The spectators drove him away, but he came again the next day, and during the whole summer there were continual skirmishes between them. The spring following, instead of one stork, came four, and attacked him all at once. A surprising event followed. All the turkies, ducks, and geese, that were brought up in the court, ran together, and formed a kind of rampart round him, against so unequal a combat. This secured him for the present : but in the beginning of the third spring, about twenty storks suddenly alighted in the court, and before the poor stork's life-guards could form themselves, or the people come to his assistance, they left him dead on the spot, which none could impute to any thing but the shot fired by Count Victor at the strange stork's nest.

The Pelican somewhat resembles a swan. The body is as large, the neck nearly as long, the legs are short, and the feet are black, broad, and webbed, in the same manner. It is also of a whitish colour, only the tips of some of his feathers are black. It is much in the waters : it has a most horrid voice, like that of a man grievously lamenting.

Its beak is above a foot in length, and the point is very sharp: the upper part is formed as in other birds, but the lower is unlike every thing in nature. It is made of two long flat ribs, with a tough membrane connected to one and the other; this reaches also to the throat, and is very broad and loose, so that it can contain a vast quantity of provision.

Its eyes are very small; there is a sadness in its countenance; and its whole air is melancholy. They are torpid and inactive to the last degree, so that nothing can exceed their indolence, but their gluttony: it is only from hunger that they labour, otherwise they would continue in a fixed repose. When they have raised themselves thirty or forty feet above the sea, they turn their head with one eye downwards, and continue to fly in that posture. As soon as they perceive a fish near the surface, they dart upon it with the swiftness of an arrow, seize it with unerring certainty, and store it up in their pouch. They then rise again, and continue hovering and fishing with their head on one side as before.

This work they continue till their bag is full, and then fly to land to devour and digest it. This they are not long performing; for towards night they have another hungry call, and they again reluctantly go to labour. At night fishing is over, and they retire a little way from the shore; and though with the webbed feet and clumsy figure of a goose, they will be contented to perch nowhere but upon trees among the light and airy tenants of the forest. There they repose for the night, and often spend great part of the day, sitting in dismal solemnity as it were half asleep. Their attitude is with the head resting upon their great bag, and that resting upon their breast: there they remain without motion till the calls of hunger break their repose.

The same indolence attends them even in preparing for incubation, and defending their young. The female makes no preparation for her nest, nor seems to chuse any place to lay in, but drops her eggs on the

bare ground, to the number of five or six, and there continues to hatch them. Without any desire of defending her eggs or her young, she tamely sits and suffers them to be taken from under her. Now and then she just ventures to peck or to cry out when a person offers to beat her off. She feeds her young with fish macerated in her bag, and when they cry flies off for a new supply.

They are but disagreeable and useless domestics; their gluttony can scarcely be satisfied; their flesh smells very rancid, and tastes a thousand times worse than it smells. The native Americans kill vast numbers; not to eat, for they are not fit even for the banquet of a savage, but to convert their large bags into purses and tobacco-pouches. They bestow no small pains in dressing it with salt and ashes, rubbing it well with oil, and then forming it to their purpose. It thus becomes so soft and pliant, that the Spanish women sometimes adorn it with gold and embroidery to make work-bags of.

Yet with all the hebetude of this bird; it is not entirely incapable of instruction. The emperor Maximilian had a tame pelican which lived for above eighty years, and always attended his army on the march.

The Albatross is one of the largest and most formidable birds of Africa and America. It is as large as a goose, of a brown colour, and is one of the most fierce of the aquatic tribe, not only living upon fish, but also such small water-fowl as it can take by surprise. It preys, as all the gull kind do, upon the wing, and chiefly pursues the flying-fish. These are every moment rising to escape from their pursuers of the deep, only to encounter equal dangers in the air. Just as they rise, the dolphin is seen to dart after them, but generally in vain. The gull has more success, and often takes them at their rise, while the albatross pursues the gull, so that the whole horizon presents but one living picture of rapacity and evasion.

But though this bird be one of the tyrants of the

deep, there are some associations which even tyrants form, either by caprice or necessity. The albatross has a peculiar affection for the penguin. They chuse the same places for breeding, some distant uninhabited island, where the ground slants to the sea, as the penguin is not formed either for flying or climbing. In such places their nests are seen together, as if they stood in need of mutual assistance. Our men upon Falkland islands were often amazed at the union preserved between those birds. In that bleak and desolate spot, where they no way dreaded the encroachments of men, they seemed to make their abode as comfortable as they expected it to be lasting. They built with an amazing degree of uniformity; their nests covering fields by thousands, and resembling a regular plantation. In the middle on high, the albatross raised its nest, built of heath, sticks, and long grass, about two feet above the surface; round this the penguins made their lower settlements, rather in holes in the ground, and most usually eight penguins to one albatross.

Nothing is a stronger proof that the presence of man not only destroys the society of meaner animals, but their instincts also. These nests are now totally destroyed, the society is broke up, and albatross and penguins have gone to breed upon more desert shores in greater security.

The Swan is as delicate in its appetite, as elegant in its form. Its chief food is corn, bread, herbs growing in the water, and roots and seeds, which are found near the margin. It prepares a nest in some retired part of the bank, and chiefly where there is an islet in the stream. This is composed of water-plants, long grass, and sticks; and the male and female assist in forming it with great assiduity. The swan lays seven or eight eggs, white, much larger than those of a goose. It sits near two months before its young are excluded, which are ash-coloured, for some months. It is dangerous to approach the old ones, when their little family is feeding round them. They soon take the

alarm, and they sometimes give a blow with their pinion that breaks a man's leg or arm.

It is not till they are a twelvemonth old that the young swans change their colour with their plumage. All the stages of this bird's approach to maturity are slow, and mark its longevity. A goose has been known to live a hundred years, and the swan is supposed to live still longer.

The Goose, in its domestic state, exhibits a variety of colours. The wild goose always retains the same marks; the whole upper part is ash-coloured, the breast and belly are of a dirty white, the bill is narrow at the base, and at the tip it is black. These marks are seldom found in the tame, whose bill is entirely red, and whose legs are entirely brown. The wild goose is rather less than the tame; but both invariably retain a white ring round the tail, which shews that they are both descended from the same original.

The wild goose breeds in the northern parts of Europe, and in the beginning of winter descends into more temperate regions. They are often seen flying at very great heights, in flocks from fifty to a hundred. Their cry is frequently heard when they are at an imperceptible distance above us: and this seems handed from one to the other, as among hounds in the pursuit.

Upon their coming to the ground by day, they range themselves in a line, and seem rather to descend for rest than refreshment. When they have sat in this manner for an hour or two, one of them, with a loud long note, sounds a kind of charge, to which the rest attend, and pursue their journey with renewed alacrity.

The wild goose seldom lays above eight eggs, the tame goose often above twenty. The female hatches her eggs with great assiduity, while the gander visits her twice or thrice a day, and sometimes drives her off to take her place, where he sits with great state and composure.

But beyond that of all animals, is his pride when the young are excluded : he seems then to consider himself as a champion : he pursues dogs and men that never attempt to molest him ; and though the most harmless thing alive, is then the most petulant and provoking. When, in this manner, he has pursued the calf or the mastiff, to whose contempt alone he is indebted for safety, he returns to his female and her brood in triumph, clapping his wings, screaming, and shewing all the marks of conscious superiority.

The Soland-Goose, somewhat less than a land goose, is white ; only the tips of its wings are black, and the top of the head yellow. The bill is long, and so sharp pointed, that it pierces an inch deep into a board, when they stoop at fish which are laid thereon : this is one way of catching them. When they sleep they put their head under their wings ; but one keeps watch. If that be surprised by the fowler, which frequently happens, all the rest are easily caught by the neck one after another. But if the sentinel cries and gives them warning, the whole flock escapes. When they fish for herrings, which come in shoals, they fly near sixty yards high, and stoop perpendicularly : but when they aim at a single fish, they descend aslant.

There is always one tribe among them which is barren : these keep together, and never mix with them that build and hatch. (Is it not probable that these are the males, like the drones among the bees?) The Soland geese come to the Western Isles in Scotland in March, taking the advantage of a south-west wind. They send a few before them who make a tour round the isles, and then return to their company. In a few days after, the whole flock comes together, and stays till September. All this time they are daily making up their nests in the shelves of high rocks. They fish, hatch, and make their nests by turns. In order to this, they amass together not only heaps of grass, but whatever else they find floating on the water. In a nest

on St. Kilda, was found a soldier's red coat, and some Molucca beans in another.

They are thought the sharpest sighted of all sea-fowls. They have a large gorget somewhat like a pelican, in which one of them will preserve five or six herrings entire, and carry them to her nest, where they empty them out for food to their young. Nay, they have been observed to go a fishing to some isles which are thirty leagues distant, and bring the fish in their gorget all that way.

In the isle of Rona (one of the Scotch Western isles) there are a couple of eagles, which the natives say, not only drive away their young as soon as they are able to fly, but keep possession of the island, not suffering any of their kind to live there but themselves.

There are also a couple of ravens in this island, which beat away all ravenous fowls. And when their own young are able to fly, they beat away them likewise.

That which in Iceland they call the Down-bird, is very remarkable: it is a species of duck, but covered with fine soft downy feathers. The drake is full as large as a goose, but the duck considerably smaller. They abound all over Iceland, but particularly the western part, on account of the islands off the coast, where chiefly they build their nests: they build them with the down they pull from their breast. They lay four green eggs as large as a goose. The inhabitants then take away both the eggs and the nest. The ducks go to work again, pull more down from their breasts, and lay four eggs more, which are again taken away by the inhabitants. This does not however discourage the duck: she builds a third nest, and lays four more eggs: but the drake is now obliged to supply the down, the duck having none left. They now let her hatch her young: for if they disturb her a third time, she builds

no more that year, nor ever returns to the same place. When the young have left the nest, they take it a third time, and so have two sets of eggs, and three parcels of down from the same nest.

The Bat seems a medium between bird and beast ; but it comes nearer to the latter. They lay themselves up and sleep for the winter months, in the driest parts of caves. There fixing their talons in the roof, they cover their bodies with their wings, and hang perpendicularly in great numbers, but so as not to touch each other.

Who can account for another matter of fact which is particularly observed on the Western Islands? The Western ocean throws up on their shores great quantities of weather-beaten timber, on which hang multitudes of little shells fastened to one another, much as muscle-shells are. In every one of these shells is a perfect fowl : the little bill is like that of a goose, the eye marked, the head, neck, breast, wings, tail, and feet formed. The feathers are perfectly shaped, and of a blackish colour, and the feet like those of other water fowl : but we cannot hear of any person that ever saw any of them alive.

Now as bats are a kind of medium between beasts and birds, are not barnacles a kind of medium between birds and fishes.

I will conclude this account of birds with one that seems to unite in itself somewhat of every class preceding. It is at once possessed of appetites for prey like the rapacious kinds, and an attachment to water like the birds of that element. It exhibits in its form the beautiful plumage of the peacock, the shadings of the humming bird, the bill of the crane, and the short legs of the swallow. The bird I mean is the King Fisher : it is not much larger than a swallow ; its shape is clumsy, the legs very small, and the bill very long ;

it is two inches from the base to the tip, but the colours of this bird atone for its inelegant form. The crown of the head and the edges of the wings are of a deep blackish green, spotted with bright azure; the back and tail are of the most resplendent azure; the whole under-side of the body is orange-coloured; a broad mark of the same passes from the bill beyond the eyes, beyond that is a large white spot; the tail is short, and consists of twelve feathers of a rich deep blue; the feet are of a reddish yellow.

From the diminutive size, and the beautiful colours of this bird, no person would be led to suppose it so rapacious an animal. It is ever on the wing, and feeds on fish, which it takes in surprising quantities, balancing itself at a certain distance above the water for a considerable space, then darting down and seizing the fish with inevitable certainty.

The king fisher, with which we are acquainted, has none of those supposed powers of allaying the storm, or building upon the waves. It is contented to make its nests on the banks of rivers, in such situations as not to be affected by the rising of the stream. When it has found a place for its purpose, it hollows out with its bill a hole about a yard deep; or if it finds the deserted hole of a rat, it takes quiet possession. This hole it enlarges at the bottom, and lining it with the down of the willow, lays its eggs there without any further preparation.

The female begins to lay early in the season, and excludes her first brood about the beginning of April. The male brings her large provisions of fish, while she is thus employed, and she, contrary to most other birds, is found fat at the season of hatching.

9. I have now only to add a few reflections.

And 1. That birds should all lay eggs, and not bring

forth live young, is a clear argument of Divine Providence, designing their preservation thereby. For if they had been viviparous, had they brought any number at a time, the burden of their womb must have been so great and heavy, that their wings would have failed, and they become an easy prey to their enemies. And had they borne but one at a time, they would have been bearing all the year.

2. Since it would have been many ways inconvenient to birds to give suck, and yet inconvenient if not destructive to the new-born chick, to pass suddenly from liquid to hard food, before the stomach was strengthened and able to digest it, and before the bird was accustomed to use its bill, and gather it up, which it does at first very slowly and imperfectly; therefore nature has provided in every egg a large yolk, which serves the chicken a considerable time instead of milk. Mean time it feeds by the mouth a little at a time, and that more and more, till the stomach is strengthened to digest it.

3. Birds that feed their young in the nest, though they bring but one morsel at a time, and have perhaps seven or eight, which all at once, with equal greediness, hold up their heads and gape for it; yet never mistake, never omit one, but feed them all by turns.

4. Though birds cannot number, yet they are able to distinguish many from few; and when they have laid as many eggs as they can cover, they give over, and begin to sit. Yet they are not determined to such a number: they can go on and lay more at their pleasure. Hens, for instance, if you let their eggs alone, lay fourteen or fifteen, and give over; but if you withdraw their eggs daily, they will go on to lay five times that number. This holds not only in domestic birds, but also in the wild. A swallow, when her eggs were withdrawn daily, proceeded to lay nineteen.

5. It is remarkable that birds, and such other oviparous creatures as are long lived, have eggs enough conceived in them at first to serve laying for many years, allowing such a proportion for every year as will suffice for one or two incubations. Whereas insects, which are to breed but once, lay all their eggs at once, be they ever so many.

6. How exceeding speedy is the growth of birds that are fed by the old ones in the nest. Most of them come to near the full bigness, within the short term of a fortnight : an admirable provision that they may not lie long in that helpless condition, exposed to the ravine of any vermin, and utterly unable to shift for themselves.

7. What amazing care do the parents take for the hatching and rearing of their young ? First, they seek out a secret and quiet place, where they may be undisturbed in their incubation. Then they make their nests, every one after his kind, that their eggs and young may be soft and warm ; and those so elegant and artificial, as no art of man can imitate.

After they have laid their eggs, how diligently do they sit upon them, scarce giving themselves time to go off to get them meat ? When the young are hatched, how diligently do they brood over them, lest the cold should hurt them ? All the while labouring hard to get them food, and almost starving themselves, lest they should want. Moreover, with what courage are they inspired, so as to venture their own lives in defence of them ? The most timorous, as hens and geese, daring then even to fly in the face of a man. And all these pains are bestowed upon those that will render them no thanks for it ! And they are bestowed just so long as is necessary ; for when the young is able to shift for itself, the old retains no such affection for it, but will beat it indifferently with others.

8. It is another proof of a superintending Providence,

that all animals are produced at the most convenient time of the year, just when there is food and entertainment ready for them. So lambs, kids, and many other living creatures, are brought into the world in the spring, when tender grass and nutritive plants are provided for their food. The like may be observed concerning silk-worms, whose eggs are hatched just when the leaves of the mulberry tree appear; the aliment being soft and tender, while the worms themselves are so, and growing more strong and substantial as the insects increase in bulk and vigour.

9. A still farther proof hereof we have in the various instincts of animals, directed to ends which they know not, as, 1. All creatures know how to defend themselves, and offend their enemies; all know what their natural weapons are, and how to make use of them. A boar knows the use of his tusks, a horse of his hoofs, a cock of his spurs, a bee of her sting. Yea a calf will make a push with his head, even before any horns appear. 2. Those creatures which have not strength to fight, are usually swift of foot or wing, and are naturally inclined to make use of that swiftness, and save themselves by flight. 3. Every creature knows and shuns its natural enemy, as a lamb does the wolf, and partridge or poultry birds of prey; and they make use of a peculiar note to warn their young of their approach, who thereupon immediately run to shelter. 4. As soon as ever it is brought forth, every animal knows its food. Such as are nourished with milk, immediately find their way to the paps, and suck; whereas those which are designed for other nourishment, never make any such attempt. 5. Birds that are fin-toed, or whole-footed, are naturally directed to go into the water. So ducklings, though hatched and led by a hen, if she brings them to the brink of a river or pond, presently leave her and go in, though they never saw any such thing before, and though the hen clucks and calls, and does all she can to keep them out. 6. Birds of the same kinds make

their nests of the same materials, laid in the same order, and exactly of the same figure, so that by the sight of the nest one may certainly know what bird it belongs to. And this, though living in distant countries, and though they never saw any nest made; that is, although they were taken out of the nest, and brought up by hand. Nor were any of the same kind ever known to make a different nest, either for matter or fashion, unless where the usual matter was not to be had; in that case, some birds use what they can get.

I would add a little farther improvement of some particulars mentioned before.

What master has taught birds that they have any need of nests? Who has warned them to prepare them in time, and not to suffer themselves to be prevented by necessity? Who hath shewn them how to build? What mathematician has given the figure of them? What architect has taught them to choose a firm place, and to build a solid foundation? What tender mother has advised them to cover the bottom with a soft and delicate substance, such as cotton or down, and when these fail, who has suggested to them that ingenious charity, to pluck off as many feathers from their own breast, as will prepare a soft cradle for their young?

Again. What wisdom has pointed out to each kind a peculiar manner of building? Who has commanded the swallow, to instance in one, to draw near to man, and make choice of his house for the building her nest, within his view, without fear of his knowing it, but seeming rather to invite him to a consideration of her labour? Nor does she band like other birds, with bits of sticks and stubble, but employs cement and mortar, and that in so firm a manner, that it requires some pains to demolish her work. And yet in all this, it has no other instrument to make use of but a little beak.

Yet again. Who has made the birds comprehend the

they must hatch their eggs by sitting upon them : that this necessity is indispensable ; that the father and mother could not leave them at the same time ; and that if one went abroad to seek for food, the other must wait till it returns ? Who has told them the precise number of days this painful diligence is to cost ? Who has taught them to assist the young in coming out of the egg, by breaking the shell for them ? Yea, and advertised them of the very moment before which they never come ?

Who has taught several of the birds that marvellous industry of retaining food and water in their gullet, without swallowing either, and preserving them for their young, to whom this preparation serves instead of milk ?

Is it for the birds, O Lord, who have no knowledge thereof, that thou hast joined together so many miracles ? Is it for the men who give no attention to them ? Is it for those who admire them, without thinking of thee ? Rather is it not thy design, by all these wonders, to call us to thyself ? To make us sensible of thy wisdom, and fill us with confidence in thy bounty, who watchest so carefully over those inconsiderable creatures, two of which are sold for a farthing ?

But pass we from the industry of birds to hearken for a moment to their music : the first song of thanksgiving which was offered on earth before man was formed. All their sounds are different, but all harmonious, and altogether compose a choir which we cannot imitate. One voice however more strong and melodious I distinguish above the rest. On enquiry, I find it comes from a very small bird. This leads me to consider the rest of the singing birds : they likewise are all small ; the great ones having a harsh and disagreeable voice. Such an amends is made to these weak little creatures for their defect of strength !

Some of these little birds are extremely beautiful, nor can any thing be more rich or variegated than their feathers : but it must be owned, that all ornament must give place to the finery of the peacock ; upon which God has plentifully bestowed all the riches which set off the rest, and lavished upon it with gold and azure all the shades of every other colour. This bird seems sensible of its advantage, and looks as if it designed to display all its beauties to our eyes, when it stalks along and expands that splendid circumference which sets them all in open view.

But this pompous bird has of all others that are kept tame, the most disagreeable cry, and is a proof that there may be a shining outside, when there is little substance within.

In examining the feathers of the rest, I find one more circumstance very observable. That feathers of swans and other water fowl are proof against the water, and accordingly they continue dry, though the creature swims or dives ever so long ; and yet neither our eyes nor all our art can discover wherein they differ from others.

I know not how to conclude this chapter without adding a few more reflections.

All the universe is replenished with life, and every part of it with its proper animals : but would one expect to see them in the air ? Nothing seems more natural to our eyes ; but nothing is more astonishing to our reason. The fact is certain, and yet might seem to be altogether impossible. A bird in flight is a mass raised aloft, in spite of the gravity of the air, and the tendency of all bodies to the earth : this mass is raised not by any foreign force, but by a movement suited to the purpose of the creature, and which sustained it in the air, for a considerable time, with a peaceful vigour.

Again. In the whole kingdom of birds, none have more than two wings, and yet they all fly in a different manner. Some launch away by repeated springs; others glide through the air with an even motion: these always skim over the earth; those soar up to the clouds. Some know how to diversify their flight by a straight oblique, or circular motion: to suspend their bodies and continue motionless in an element lighter than themselves: after this, to start into a horizontal motion, and then dart either to the right or left, wheel into a contrary tract, remount, and then precipitate themselves like a descending stone: in a word, they transport themselves without opposition or hazard wherever their necessities or pleasures call them.

The structure of their nests, the care with which they attend their eggs, the mechanism of the egg itself, and the birth and education of their young, are equally astonishing. See the perfect similitude that appears in all the nests of birds of the same species, the constant difference between the nests of one species and another; together with the neatness and precaution which all of them observe. One species builds its nest on the top of trees, another on the ground, under a canopy of grass, but always with a shelter, either of herbs or a branch, or a double roof of leaves, down which the rain slides, without entering the opening which lies concealed below. The outward parts of the nest is made of solid materials, thorns, reeds, clay, or compact moss; the inner of softer materials closely interwoven, so as to keep out both winds and insects. But each species has a peculiar taste. When the building is completed some hang the inside with a tapestry of feathers, or quilt it with wool or silk.

How admirably does this display the wisdom of Him who furnished man with reason, which extends to every thing around him, and inspired animals with an imitation of it, limited indeed to a few points, but ad-

mirable in that limitation? For who informed the bird that she should lay eggs, and want a nest to lodge and nourish them with genial heat? That this heat would not be concentrated round the eggs, if the nest were too large, and that were it smaller it would not be capable of containing all the young? Who has taught her not to mis-calculate the time, or lay her eggs before she has completed her nest?

The same wisdom will more fully appear, if we observe what the egg contains, with the manner how the young is there formed, and how it issues from its confinement.

The yolk lies in the heart of the egg, inclosed in the first membrane, which is surrounded by the second. Near the centre of the egg are the ligaments that sustain the yolk, which is contained in a peculiar membrane. A second membrane incloses the first white, a third and fourth encompasses the whole. The shell is formed last of all out of the salts evacuated from all the humours of the body, which the heat gradually fixes and consolidates, to serve a double purpose, first that it may be excluded without crushing the contents; secondly, to defend their young, till it is thoroughly formed, and ready to forsake the egg.

Under the membrane which surrounds the yolk is a white speck, which is the seed of the chick in miniature. If the smallest portion of the vital spirit be infused into it from the male, by a process of which we have no idea, in the instant the chick receives life, and the whole substance is in motion. If it is not infused, the egg may indeed be laid, but it never comes to a living creature.

The pulsation of the heart bears some analogy to the pendulum of a clock, from whose vibrations the whole machine derives all its motions: the moment the heart begins to beat, the animal is alive, and receives by the umbilic duct, the nourishment which it trans-

mits to the other vessels, whose branches distribute it to the whole body. All those little canals which were flat before, are now swelled and enlarged : the whole substance imbibes a proper aliment, and the chick begins to grow.

In this situation of the speck out of which it is formed, one circumstance is highly remarkable. This minute particle which is lodged on the film that includes the yolk is always near the centre of the egg, and toward the body of the dam, in order to be impregnated with a necessary warmth ; but in how admirable a manner is this effected ? The yolk is sustained by two ligaments, which fasten it on each side to the common membrane, that is glued on the shell. A line drawn from one ligament to the other would not pass through the middle of the yolk, but above the centre, and cut the yolk in two unequal parts, so that the smaller part which contains the seed, is of necessity raised towards the belly of birds that sit : the other part as necessarily subsides, so that let the egg turn as it will, the young receives no hurt, but still enjoys a warmth that puts all about it in motion. So it feeds at ease, first on the white, which is more thin and delicate, and afterwards on the yolk, which affords more substantial nourishment. When his bill is hardened, and he grows uneasy at his confinement, he pecks and breaks the shell, and issues out fully replenished with the yolk, which nourishes him a little longer, till he is strong enough to raise himself upon his feet, and can march about to look for provisions.

CHAPTER III.

OF FISHES,

1. The number of Fishes.	9. Fins:
2. Their Covering.	10. Experiments on Fish.
3. Their Brain.	11. Of Shell-Fish.
4. Organs of Sense:	12. Of the Generation of Fishes.
5. Gills or Lungs:	13. Of some particular Sorts of Fishes.
6. Heart:	14. General Reflections.
7. Air-Bladder:	
8. Stomach:	

THE ocean is the great receptacle of fishes. It has been thought by some, that all fishes are naturally of the salt element, and that they have mounted up into fresh water by some accidental migrations. A few still swim up rivers [to deposit their spawn; but the great body of fishes, of which the size is enormous, and the shoals endless, keep to the sea, and would expire in fresh water. In that extensive and undiscovered abode, millions reside, whose manners are a secret to us, and whose very form is unknown. The curiosity of mankind, indeed, has drawn some from their depths, and his wants many more. With the figure of these at least he is acquainted: but for their pursuits, societies, antipathies, pleasures, times of gestation, and manner of bringing forth these, all are hidden in the turbulent element that protects them.

1. The number of fish to which we have given names, and of the figure, at least, of which we know something, are above four hundred. Thus to appearance the history of fish is tolerably copious, but when we come to examine, it will be found the greatest part of these we know very little of.

2. As most animals that live upon land have a covering to keep off the injuries of the weather, so all that live in the water are covered with a slimy glutinous matter, that, like a sheath, defends their bodies from the surrounding fluid. This substance, secreted from the pores of the animal's body, serves not only to defend but to assist the fish's easy progress through the water. Beneath this, in many kinds, is found a strong covering of scales, that, like a coat of mail, defends it still more powerfully, and under that, before we come to the muscular parts of the body, an oily substance, which supplies the requisite warmth and vigour.

3. It is observable in all, that though their heads are much larger in proportion to their bodies, yet their brain is considerably less than that of other animals. It consists of only two small ventricles placed in the fore-part of the head.

4. Their organs of sense do not much differ from those of other animals; but in their eyes this is peculiar, that they are quite spherical, and that the optic nerves, in coming from the brain, cross each other: whereas in other animals they incline a little to each other, but do not meet. A protuberant eye would have been inconvenient for fishes, by hindering their motion in so dense a medium, and their continually brushing through the water would have been apt to wear their eyes; therefore their cornea is flat: but to make amends for this, and for the refraction of water, different from that of air, the wise Creator has made their crystalline spherical, which in other animals is

more flat. It was formerly believed they did not hear at all; but from later experiments, there is reason to believe that several species of them do hear, though but in a low degree. Over the two holes in their head, which serve for smelling, a fine membrane is spread, by which means they can open and shut them at pleasure; a contrivance highly necessary for creatures that live in the water.

The sense of smelling which in beasts is so exquisite, and among birds is not wholly unknown, seems given to fishes in a very moderate proportion. It is true that all fishes have one or more nostrils, and even those that have not the holes perceptible without, yet have the proper formation of the bones for smelling within. But as air is the only medium we know, for the distribution of odours, it cannot be supposed that these animals residing in water can be possessed of any power of being affected by them. If they have any perception of smells, it must be in the same manner as we distinguish by our taste; and it is probable, the olfactory membrane in fishes, serve them instead of a distinguishing palate: by this they judge of substances that first tincturing the water with their vapours, are thus sent to the nostrils of the fish, and no doubt produce some kind of sensation. This most probably must be the use of that organ in those animals, as otherwise there would be the instrument of a sense provided for them, without any power in them of enjoyment.

Hearing in fishes is found still more imperfect, if it be found at all. Certain it is, that anatomists have not been able to discover, except in the whale kind, the smallest traces of an organ of hearing, either within or without the head. Indeed, of what advantage would this sense be to animals that are incapable of making themselves heard? They have no voice to communicate with each other, and consequently have no need of an organ for hearing.

Seeing seems to be the sense which fishes are possessed of in the greatest degree. And yet even this is obscure, if we compare it to that of other animals. The eye, in almost all fish, is covered with the same transparent skin that covers the rest of the head, and which probably serves to defend it from the water, as they are without eye-lids. The globe of the eye is depressed before, and is furnished behind with a muscle which serves to strengthen or flatten it, according to the necessities of the animal. The crystalline humour, which in beasts is flat, and of the shape of a button mould, in fishes is as round as a pea, or sometimes oblong like an egg.

From all this, it appears that fishes are extremely near-sighted, and that even in the water they can see objects only at a very small distance.

Thus nature seems to have fitted these animals with appetites and powers of an inferior kind, and formed them for a sort of passive existence in the obscure and heavy element to which they are consigned: to preserve their own existence, and to continue it to their posterity, fill up the whole circle of their pursuits and enjoyments.

5. Some fishes have lungs, but in the greater part the place of them is supplied by gills. As we take in and throw out the air by our lungs, so they take in the air, mixed with the water, by their mouth, and throw it out by their gills.

There is always much air enclosed in water. This the gills separate from it, and present to the blood, as it is presented in the lungs of other animals. Each gill contains a great number of bony laminae, consisting of an infinity of bony fibres, that sustain the innumerable ramifications of the veins and arteries, which present the blood extremely sub-divided, and as it were, each globule by itself to the water: between the laminae, through the whole contexture of the gills,

are an infinity of very narrow passages, which receive and divide the water taken in by the mouth, into minute particles. Then the air, its prison-doors being in some measure opened, escapes and joins the blood of all the little arteries.

The gills have an alternate motion of dilatation and compression. When they dilate, the water is taken in ; when they contract, it is driven out. It seems that in the instant of contraction, the air expressed from the water is forced into the blood-vessels. It is the same, as to our lungs. The air enters them at the time of inspiration, but is received into the blood at the time of expiration only. So that the water which is taken in by the mouth of fishes, when stripped of its air, is carried off by the gills. Meantime the air which is thus gained is distributed first to those fine ramifications of the arteries, which are expanded upon the gill throughout, and then to the veins inosculated therewith. And fishes can no more live without a constant supply of this, than land animals can.

The gills in all fishes are eight, four on each side. The lower gill is always smaller than the rest. The other three on each side are gradually larger to the top one, which is always the largest. Each of these is formed of a bony substance, bent into the shape either of a semicircle or a bow. On the convex side of this, there is a sort of plumes or leaves, each of which consists of a double row of bony lamella, formed like so many sickles, and fixed to the convex side of the bow by means of the membrane wherewith it is covered.

These lamella have one part convex, and the other concave. The concave part of each lamella is applied to the convex part of the next opposite lamella. Every lamella is invested with a fine membrane, which receives the ramifications of the blood-vessels. Every gill has an artery, a vein and a nerve. The gills receive the blood which is thrown from the heart into the aorta, and derive it to the utmost parts of the

lamella, from whence it returns by veins which distribute it throughout the body.

6. In most fishes the heart is like that in other animals. But in some it has only one ventricle ; which necessarily occasions a difference in the manner wherein the blood circulates. In some also the blood is not red, but clear and transparent. In others, especially shell-fish, besides the arteries and veins, there are open tubes, which convey the water to the farthest part of them : probably that they may find no want of water, when they continue some time on shore.

7. The air-bladder is described as a bag filled with air, sometimes composed of one, sometimes of two, and sometimes of three divisions, situated towards the back of the fish, and opening into the maw or the gullet. It is commonly supposed, by its swelling at the will of the animal, to increase the surface of the fish's body, and so to enable it to rise to the top of the water, and keep there at pleasure. On the contrary when the fish wants to descend, it is supposed to empty this bladder of its air, and to sink to the bottom.

But many fishes have an air bladder, that continually crawl at the bottom ; such as the eel and the flounder : and many more are entirely without it, that swim in every depth ; such as the anchovy and the fresh-water gudgeon. Indeed, the number of fishes that want this organ is alone a sufficient proof that it is not necessary for the purposes of swimming ; and the ventral fins, which in all fishes lie flat upon the water, are fully sufficient to keep them at all depths.

8. The stomach is, in general, placed next the mouth, and though not sensibly hot, is endued with a surprising faculty of digestion. Its digestive power seems in some measure to increase with the quantity

of food it is supplied with ; a single pike having been known to devour a hundred roaches in three days. Its faculties also are as extraordinary, for it digests not only soft fish, but prawns, crabs and lobsters, shells, and all. These the cod or the sturgeon will not only devour, but dissolve, though their shells are so much harder than the sides of the stomach which contains them. This amazing faculty in the cold stomach of fishes has justly excited the curiosity of philosophers : and has effectually overturned the system of those who suppose the heat of the stomach is alone a sufficient instrument for digestion. The truth seems to be, that there is a power of animal assimilation lodged in the stomach of all creatures, which we can neither describe nor define, converting the substances they swallow into a fluid, fitted for their own peculiar support. This is done neither by trituration, nor by warmth, nor by motion, nor by a dissolving fluid ; but by some principle yet unknown, which acts in a different manner from all kinds of artificial maceration.

Yet though fish are thus hungry, and for ever prowling, no animal can suffer the want of food for so long a time. The gold and silver fish which we keep in vases, seem never to want any nourishment at all ; whether it be that they feed on the water-insects, too minute for our observation, or that water alone is a sufficient supply. Even the pike, the most voracious of fishes, will live in a pond where there is none but himself, and what is more extraordinary, will be often found to thrive there.

Air however is so necessary to all fish, that they can live but a few minutes without it : yet nothing is more difficult to be accounted for, than the manner in which they obtain this necessary supply. Those who have seen a fish in the water, must remember the motion of its lips and its gills, or at least of the bones on each side that cover them. This motion in

the animal is without doubt, analogous to our breathing, but it is not air, but water, that the fish actually takes in and throws out through the gills at every motion.

The manner of its breathing seems to be this. The fish first takes a quantity of water by the mouth, which is driven to the gills, these close and keep the water so swallowed from returning by the mouth, while the bony covering of the gills prevents it from going through them, until the animal has drawn the proper quantity of air from the body of water thus imprisoned : then the bony covers open and give it a free passage ; by which means also the gills again are opened, and admit a fresh quantity of water. Should the fish be prevented from the free play of its gills, or should the bony covers be kept from moving, by a string tied round them, the animal would soon fall into convulsions and die in a few minutes.

9. The chief instruments in a fish's motion are the fins, which in some are much more numerous than in others. A fish completely fitted for sailing is furnished with two pair ; also three single fins, two above and one below. Thus equipped it migrates with the utmost rapidity, and takes voyages of a thousand leagues in a season. But such fish as have the greatest number of fins have not always the swiftest motion. The shark is one of the swiftest swimmers, yet it wants the ventral fins ; the haddock does not move so swift, though it has them.

The fins not only assist the animal in progression, but in rising or sinking, in turning, or even leaping out of the water. To answer these purposes, the pectoral fins serve like oars, to push the animal forward. They are placed behind the opening of the gills ; they are generally large and strong, and answer the same purposes to the fish as wings do to a bird. Those also balance the fish's head, when it is too

large for the body, and keep it from tumbling prone to the bottom, as is seen in large headed fishes, when the pectoral fins are cut off. Next these are the ventral fins, placed under the belly. These are always seen to lie flat on the water, in whatever situation the fish may be ; and they serve rather to raise or depress the fish, than to assist its progressive motion. The dorsal fin is situate along the ridge of the back ; and serves to keep it in equilibrio. In many fishes this is wanting ; but in all flat fishes it is very large, as the pectoral fins are proportionably small. Lastly, the tail, which in some fishes is flat, and upright in others, seems the grand instrument of motion ; the fins are subservient to it, and give directions to its impetus, by which the fish darts forward with so much velocity. To explain all this, by experiment, a carp is taken, and put into a large vessel. The fish, in a state of repose, spreads all its fins, and seems to rest upon its pectoral and ventral fins near the bottom : if the fish folds up either of its pectoral fins, it inclines to the lame side ; folding the right pectoral fin, the fish inclines to the right side ; folding the left fin, it inclines to that side. When the fish desires to have a retrograde motion, striking with the pectoral fins, in a contrary direction produces it. If the fish desires to turn, a blow from the tail sends it about ; but if the tail strikes both ways, then the motion is progressive.

10. There is something extremely odd in the experiments of an ingenious man, on some of our common fishes.

“ I put a banstickle, says he, in a glass jar filled with water : at first it refused to eat any thing, which is common with all fishes ; but afterward it grew so tame as to take small worms out of my hand. Nay, it was so bold at last, that when its belly was full, it would set up its prickles, and with all its strength, make a stroke at my fingers, if I put them near it.

“This fish was so unsociable, that it would suffer no other fish to live in the jar with it, and so audacious as to attack whatever I put in, though ten times its own size. One day I put in a small ruff; the banstickle instantly assaulted it, and tore off part of its tail, and I am persuaded would have killed it, had I not separated them.

“The abilities they use to get from place to place, are likewise extraordinary. Though they are scarce two inches long, I have seen them leap out of the water a foot high perpendicularly, and much farther obliquely, when they wanted to get over some obstacle in their way.

“Nature has furnished them with a kind of breast-plate, to be a defence against outward injury, and with prickles upon their sides and back, which they erect on the least appearance of danger.

“I have always observed among the fish I keep in jars, that such as I keep awhile together, contract so great an affection for each other, that if they are separated, they grow melancholy and sullen. About Christmas I put two ruffs into a jar, where they lived together till April. I then gave one of them to a friend, the other was so affected, that for three weeks it would eat nothing. Fearing it would pine to death, I sent it to its companion: being put to this, it ate immediately, and presently recovered its former briskness.”

“In the beginning of September,” says the same gentleman, “I procured a small dace, which I kept in a glass jar till the latter end of May following. All this while it ate nothing except the small animalcules, which happened to be in the water. I gave it, once a day in winter, twice or thrice in the spring, as the weather grew warmer. When the water was fresh, it came up to the top about once an hour, to blow out some small bubbles of air. Then putting its nose near the surface, it took in fresh, and retired to the bottom again. But as the water became less

pure by its use, its returns to the surface were more frequent, and at last it would remain there continually, till I gave it a fresh quantity. I believe I might have kept it for years, but business one day prevented me from giving it clean water in due time, which put a period to the life of my little companion.

“At first it would not suffer me to come nigh the glass, without the utmost confusion and surprise; but at last it grew so tame, that if I came but in sight, it would be sure to be at the same side of the glass, and lie gazing at me, until I was weary of observing it. I often took the opportunity of looking at it by candle-light, which it seemed to take great pleasure in.

“In the above-mentioned month, I put into another glass, a ruff about three inches long. At first he too appeared mighty reserved, and would not eat, nor suffer me to come nigh him; but in a short time all-powerful hunger tamed him: for he could not like the dace, live on the small inhabitants of the water, and so was quickly forced to take whatever I provided for him. In awhile it grew so tame that it would not only eat small worms which I threw into the glass, but would take them out of my hands. Nay, it would even rise out above the water for them; which is contrary to the way wherein this kind of fish uses to take its food. At last it would come to my hand, whenever I put it into the glass, and suffer me to handle it. When I had made all the observations I thought proper, after eight months I gave him his liberty.”

11. It has long been supposed that all shells, as well as the animals in them, arose wholly from the egg. But it is now found by various experiments, that the shells of snails (and probably of all other animals) are formed of a matter which perspires from their bodies, and then condenses round them.

It is certain all animals perspire and are encompassed with an atmosphere which exhales from them. Snails have nothing peculiar in this respect, unless that their atmosphere condenses and hardens about them, and forms a visible cover for the body, while that of other animals evaporates. This difference may arise from the different substance perspired ; that from snails being viscous and stony. This is no supposition, but a matter of fact, proved by numerous experiments.

But the re-production of the shells of some fish, yea, and of the parts contained therein, is far more strange and unaccountable, than their first production. This is particularly observed in crabs and lobsters. Lobsters cast their shell yearly, some time after midsummer. In the room of the old, a new, thin shell is immediately prepared by nature, which in less than eight days, acquires almost the same degree of hardness as the other.

The legs of a lobster consist of five articulations. When any of these legs break, which frequently happens, the fracture is always near the fourth joint, and what they lose is precisely reproduced in some time after : four joints shooting out, the first whereof has two claws, as before.

If a leg be broken off purposely at the fourth or fifth joint, it is constantly reproduced : but very rarely, if at the first, second, or third joint. What is still more supprising is, that upon visiting the lobster, which is maimed in these barren articulations, at the end of two or three days, all the other joints are found broken off at the fourth, which he has undoubtedly done himself.

The part re-produced is perfectly like that broke off, and in a certain time grows equal to it. Hence it is, that lobsters have often their two big legs unequal. This shews the smaller leg to be a new one. If a part thus re-produced is broken off, there is a second reproduction. The summer, which is the

only time when lobsters eat, is the most favourable time for this. It is then performed in four or five days; otherwise it takes up eight or nine months.

The common crab-fish has its abode from twenty to forty fathom water. They herd together in distinct tribes, and have their separate haunts for feeding and breeding, and will not associate with their neighbours. This has been tried by marking a crab, carrying it two or three miles, and leaving it among other crabs. This crab has afterward found its way home, and been caught in its old abode.

This creature too can break off its own limbs. If when it is laid on its back, one of the outer joints of a small leg be bruised, he shews uneasiness, by moving it about. Afterward he holds it quite still, in a direct and natural position, without touching any part of the body, or of the other legs with it. Then on a sudden with a gentle crack, the wounded part of the leg drops off. If a hole be pierced in the great leg, the effect will be the same; and the large limb is thrown off in the same manner, only with greater violence. A mucus then overspreads the wound, which presently stops the bleeding; and a small leg is by degrees produced, which gradually attains the size of the former. Nature has given this singular power to these creatures, for the preservation of their lives in their frequent quarrels. In these, one crab lays hold of the claw of another, and crushes it in such a manner, that it would bleed to death, had it not the power of giving up the limb, and healing the wound.

However different in figure the lobster and the crab may seem, their manners are nearly the same. Though without any warmth in their bodies, or even red blood, they are wonderfully voracious. Whatever they seize upon that has life, is sure to perish, though never so well defended: they even devour each

other ; and, to increase our surprise, they may in some measure, be said to eat themselves, as they change their shell and their stomach every year, and their old stomach is generally the first morsel that serves to glut the new.

What this animal differs in from all others, is, that the spinal marrow is in the breast-bone. It is furnished with two long feelers or horns, that issue on each side of the head, to correct the dimness of its sight, and apprize the animal of its danger, or of its prey. The tail is the grand instrument of motion ; and with this it can raise itself in the water.

When the young lobsters leave the parent, they seek for refuge in the smallest clefts of rocks, and in crevices at the bottom of the sea. There they grow larger in a few weeks, from the accidental substances which the water washes to their retreats. By this time also they acquire a hard firm shell, which furnishes them with both offensive and defensive armour. They then issue from their fortresses, and creep along the bottom, in hopes of meeting with plunder. The spawn of fish, the smaller animals of their own kind, but chiefly the worms that keep at the bottom of the sea, supply them with plenty. They keep in this manner close among the rocks, busily employed in scratching up the sand with their claws for worms, or surprising such heedless animals as fall within their grasp : thus they have little to apprehend, except from each other, for in them, as among fishes, the large are the most formidable of all enemies to the small.

But the body of the lobster still continuing to increase, the animal soon becomes too large for its habitation. In general all animals change their shell once a year ; and this is a most painful operation. Their moulting season is generally about the beginning of summer ; at which time their food is plenty, and their strength and vigour in the highest perfection. But soon all their activity ceases : they seek some retired situation among the rocks, where they remain in safety from

the attacks of their various enemies. For some days before their change, the animal discontinues its usual voraciousness ; it is no longer seen harrowing up the sand at the bottom, or fighting with others of its kind, or hunting its prey : it lies torpid and motionless. Just before casting its shell, it throws itself upon its back, strikes its claws against each other, and every limb seems to tremble ; its feelers are agitated, and the whole body is in violent motion. It then swells itself in an unusual manner, and at last the shell begins to divide at its junctures ; particularly at the junctures of the belly, where like a pair of jumps, it was before but seemingly united. It also seems turned inside out ; and its stomach comes away with its shell. After this it disengages itself of the claws, which burst at the joints ; the animal, with a tremulous motion, casting them off, as a man would kick off a boot that was too big for him.

Thus this wonderful creature is at liberty ; but so weak that it continues for several hours motionless. Indeed, so violent and painful is the operation, that many of them die under it ; and those which survive, for some time neither take food, nor venture from their retreats. Immediately after this change, they have not only the softness, but the timidity of a worm. Every animal of the deep is then a powerful enemy, which they can neither escape, nor oppose, and this is the time when the dog-fish, the cod, and the ray devour them by hundreds. But this state continues for a very short time : in less than two days, the skin that covered its body is grown almost as hard as before.

When the lobster is completely equipped in its new shell, it appears how much it has grown in the space of a very few days. The old shell being compared with those of the new, it is increased above a third in its size ; and, like a boy that has outgrown his clothes, it seems wonderful how the deserted shell was able to contain so great an animal as entirely fills up the new.

It may be worth observing, that lobsters use their tails as fins, wherewith they commonly swim backward, by jerks or springs, reaching sometimes ten yards at a spring. For this purpose, as the gill-fins of other fishes, which are their oars, are a little concave backward, these have the plates of their tails, when they bend them down as they use to do, a little concave forward.

Different from all these are the land crabs of the Caribbee islands; which live in a kind of orderly society, within their retreats in the mountains; and regularly once a year march down to the sea side in a body of some millions. They chuse the months of April and May to begin their expedition: and then sally out from the stumps of hollow trees, from the clefts of rocks, and from the holes which they dig for themselves under the surface of the earth. At that time the whole ground is covered with this band of adventurers. The sea is their place of destination, and to that they direct their march. No geometrician could send them to their destined station, by a shorter course. They never turn to the right or left, whatever obstacles intervene. And even if they meet with a house, they will attempt to scale the walls, to keep the unbroken tenor of their way. But upon some occasions they are compelled to conform to the face of the country; and if it be intersected by rivers, they wind along the course of the stream. They are commonly divided into three battalions; of which, the first consists of the strongest and boldest males, that like pioneers, march forward to clear the route, and face the greatest dangers. These are often obliged to halt for want of rain, and wait till the weather changes. The main body of the army is composed of females, which never leave the mountains till the rain is set in, and then descend in regular battalia, in columns of fifty paces broad, and three miles deep, and so close, that they almost cover the ground. Three or four days after this, the rear-guard follows; a straggling undis-

ciplined tribe, consisting of males and females, but neither so robust, nor so numerous as the former. The night is their chief time of proceeding; but if it rains by day, they do not fail to profit by the occasion. And they continue to move forward in their slow, uniform manner. When the sun shines hot, they make an universal halt, and wait till the cool of the evening. When they are terrified they march back in a disorderly manner, holding up their nippers with which they sometimes tear off a piece of the flesh of an assailant, and leave the weapon where they inflicted the wound. They often clatter their nippers together, as if it were to threaten those that come to disturb them. But though they thus strive to be formidable to man, they are much more so to each other; for if any of them by accident is maimed in such a manner, as to be incapable of proceeding, the rest fall upon and devour it on the spot, and then pursue their journey.

When after a fatiguing march, perhaps of three months, they arrive at their destined port, they prepare to cast their spawn. The peas are as yet within their bodies, and not as is usual in animals of this kind, under the tail. And the creature waits for the benefit of the sea-water, to help the delivery. For this purpose, the crab has no sooner reached the shore, than it eagerly goes to the edge of the water, and lets the waves wash over its body, two or three times. Then they withdraw to seek a lodging upon land: in the mean time, the spawn grows larger, is excluded out of the body, and sticks to the barbs under the tail. In this state of pregnancy, they once more seek the shore, and shaking off the spawn into the water, leave it there. At this time whole shoals of hungry fish are in expectation of this annual supply. The sea to a great distance is black with them; and about two thirds of the crabs eggs are immediately devoured. The eggs that escape are hatched under the sand; and soon after millions at a time of

these little crabs are seen quitting the shore, and slowly travelling up to the mountains.

The old ones however are not so active to return ; they are become so feeble, that they can hardly creep along. Most of them therefore, are obliged to continue in the flat parts of the country till they recover, making holes in the earth, which they cover at the mouth with leaves and dirt. There they throw off their old shells. At that time they are quite naked, and almost without motion for six days. They have then under their stomachs four large white stones, which gradually decrease in proportion as the shell hardens, and when they come to perfection, are not to be found. It is at that time the animal is seen slowly making its way back, and all this is commonly performed in six weeks.

There is likewise an animal of the lobster-kind that annually descends from its mountains, not only to produce an offspring, but to provide itself a covering ; not only to secure a family, but to furnish a house. I mean the Soldier Crab. It is about four inches long, has no shell behind, but is covered down to the tail with a rough skin, terminating in a point. But what nature has denied this animal, it takes care to supply by art ; and taking possession of the deserted shell of some other animal, it resides in it, till, by growing too large for its habitation, it is under the necessity of a change. It is a native of the West India Islands, and every year descends from the mountains to the sea-shore, to deposit its spawn, and to provide itself with a new shell. Its first care is to provide for its offspring, and it is thought, from the number of little shells which it is seen examining, that it deposits its spawn in them, which thus is placed in perfect security till the time of exclusion.

It is then mindful of itself. It is still seen in its old shell, which it has considerably outgrown : a part of the naked body is seen at the mouth of it, which

the habitation is too small to hide. A shell therefore, is to be found large enough to cover the whole body ; and yet not so large as to be unmanageable. To answer both these ends is no easy matter, nor the attainment of a slight enquiry. The little soldier is seen busily parading the shore along that line of pebbles and shells that is formed by the waves ; still, however, dragging its old habitation at his tail ; unwilling to part with one shell, till it can find another more convenient. It is seen stopping at one shell, turning it and passing it by, going on to another, contemplating that for awhile, and then slipping its tail from its old habitation to try on the new. This also is found to be inconvenient, and it quickly returns to its old shell again. In this manner it frequently changes, till at last it finds one, light, roomy, and commodious. To this it adheres, though the shell be sometimes so large as to hide the body of the animal, claws and all.

Yet it is not till after many trials, and many combats also, that the soldier is thus completely equipped. For there is often a contest between two of them, for some well-looking shell. They both endeavour to take possession : they strike with their claws ; they bite each other, till the weakest is obliged to yield. It is then that the victor takes possession, and parades in his new conquest three or four times backward and forward upon the strand, before his envious antagonist.

Crabs-eyes, so called, are found in the bodies of cray-fish. Each fish produces two yearly, one on each side of the stomach, between the coats of it. Here it grows, coat upon coat, and is supplied with petrifying juices, by vessels opening on the inner surface of the outward coat. The first scale, whereof all the others are formed, may be perceived in the centre ; the brims or circumferences of many of the rest being likewise apparent. It is believed, that they cast these stones with their shells yearly ; but this is

not the case. For about the time of casting their shell, the stones break through the internal coat of the stomach, and being thrown by the three serrated teeth therein, become dissolved in the space of a few days, which makes it difficult to find them just at this time.

They eat their old shells immediately after shedding them. Perhaps these stones may be designed to furnish new petrescent juices to its fluids, for the re-production of their annual dress.

As to turbinated shell-fish of the snail-kind, we may first observe the snail itself. This is surprisingly fitted for the life it is to lead. It has the organs of life in a manner almost as complete as the largest animal; a tongue, brain, salival ducts, glands, nerves, stomach, and intestines; liver, heart, and blood vessels: besides this it has a purple bag that furnishes a red matter to different parts of the body, together with strong muscles, that hold it to the shell, and which are hardened like tendons at their insertion.

But these it possesses in common with other animals. We must now see what it has peculiar to itself. The first striking peculiarity is, it has got its eyes on the points of its largest horns. When the snail is in motion, four horns are seen distinctly: but the two longest deserve peculiar consideration, both on account of the various motions with which they are endued, and of their having eyes at the extreme ends of them. These appear like two blackish points. The animal can direct them to different objects at pleasure, by a regular motion out of the body; and sometimes it hides them by a very swift contraction into the belly. Under the small horns is the animal's mouth; and though it may appear too soft a substance to be furnished with teeth, yet it has no less than eight of them, with which it devours leaves and other substances seemingly harder than itself.

It may seem whimsical to make a distinction between the animal perfections of turbinated and bivalve shell-fish, or to grant a degree of superiority to the snail above the oyster. Yet this distinction apparently obtains in nature; and we shall find the bivalved tribe of animals in every respect inferior to the other. Inferior in all their sensations; inferior in all their motions; but peculiarly inferior in their system of animal generation. The snail tribe are hermaphrodite; but require the assistance of each other for fecundation; all the bivalve tribe are hermaphrodite in like manner, but they require no assistance from each other towards impregnation; and a single muscle or oyster, if there were no other in the world, would quickly replenish the ocean.

The multitude of muscles is in some places very great; but from their defenceless state, the number of their destroyers are in equal proportion. The crab, the cray-fish, and many other animals are seen to devour them; but the tochus is their most formidable enemy. When their shells are found deserted, if we then observe closely, it is most probable we shall find that the tochus has been at work in piercing them. There is scarce one of them without a hole in it; and this probably was the avenue by which the enemy entered to destroy the inhabitant.

But notwithstanding the number of this creature's animated enemies, it seems still more fearful of the agitations of the element in which it resides; for if dashed against rocks, or thrown far on the beach, it is destroyed without a power of redress. In order to guard against these, which are to this animal the commonest and the most fatal accidents, although it has a power of slow motion which I shall presently describe, yet it endeavours to become stationary, and to attach itself to any fixed object it happens to be near. For this purpose it is furnished with a very singular capacity of binding itself by a number of threads to whatever object it approaches; And these Reaumur sup-

poses it spins artificially, as spiders their webs, which they fasten against a wall. Be this as it will, nothing is more certain than that the muscle is found attached by these threads to every fixed object; sometimes, indeed, for want of such an object, these animals are found united to each other, and though thrown into a lake separately, they are taken out in bunches of many together.

To have some fixed resting place where the muscle can continue, and take in its accidental food, seems the seat that this animal chiefly desires. Its instrument of motion by which it contrives to reach the object it wants to bind itself to, is that muscular substance resembling a tongue, which is found long in proportion to the size of the muscle. This the animal has a power of thrusting out of its shell; and with this it is capable of making a slit in the sand at the bottom. By means of this furrow it can erect itself upon the edge of its shell: and thus continuing to make the furrow in proportion as it goes forward, it reaches out its tongue, that answers the purpose of an arm, and thus carries its shell edge-ways, as in a groove, until it reaches the point intended. Then where it determines to take up its residence, it fixes the ends of its beard, which are glutinous, to the rock, or the object whatever it be; and thus like a ship at anchor, braves all the agitations of the waters. Sometimes the animal is attached by a large number of threads; sometimes but by three or four, that seem scarce able to retain it. When the muscle is fixed in this manner, it lives upon the little earthy particles that the water transports to its shells, and perhaps the flesh of the most diminutive animals. However, it does not fail to grow considerably; and some of this kind have been found a foot long. I have seen the beards of a foot and a half; and of this substance the natives of Palermo make gloves and stocking.

Oysters usually cast their spawn in May, which at first appears like drops of candle-grease, and stick to

any hard substance they fall upon. These are covered with a shell in two or three days, and in three years the animal is large enough to be brought to the market.

The Scallop is particularly remarkable for its method of moving forward upon land, or swimming upon the water. When it finds itself deserted by the tide, it moves towards the sea in a most singular manner. It first gapes with its shell as widely as it can, the edges being often an inch asunder; then it shuts them with a jerk, and by this the whole animal rises five or six inches from the ground. It thus tumbles any how forward, and renews the operation until it has attained its journey's end. When in the water it is capable of supporting itself on the surface; and there opening and shutting its shells, it tumbles over and over, and makes its way with some celerity.

The Razor-shell has a very different kind of motion. As the former moves laboriously forward, so the razor-shell has only a power of sinking downward. The shells of this animal resemble nothing so much as the haft of a razor; and by this form it is enabled to dive into the soft sand. All its motions are confined to sinking or rising a foot downwards or upwards in the sand, for it never leaves the spot where first it was planted. From time to time it raises about half way out of its hole: but if any way disturbed sinks perpendicularly down again. Just over the place where the razor buries itself, there is a small hole like a chimney, through which the animal breathes or imbibes the sea water. Upon the desertion of the tide, these holes are easily distinguished by the fishermen; and their method of enticing the razor up is by sprinkling a little sea-salt upon the hole. This melting, no sooner reaches the razor below, than it rises instantly, and shews above half its length above the surface. This appearance is instantaneous; and if the fisher does not seize the opportunity, the razor buries itself

to its former depth. There it continues secure; no salt can allure it a second time; but it remains unmolested unless the fisher will be at the trouble of digging it out, sometimes two feet below the surface.

Multivalve shell-fish may be considered as animals shut up in round boxes. To view their habitations externally, one would be little apt to consider them as the retreats of living creatures; and still less, to suppose that some of them carry their boxes with a tolerable share of swiftness, so as to escape their pursuers. Of these there are principally two kinds; such as move, and such as are stationary: the first are usually known in our cabinets by the name of sea-eggs; the others are often admired for the cavities which they scoop out for their habitation in the hardest marble. The first are called, by naturalists, Echini, or urchins: the latter are called Pholades, or filefish. Of both these are several sorts; but by describing these two, we shall have a competent idea of all the rest.

To a slight view, the Sea-urchin may be compared to the husk of a chesnut; being like it, round and with a number of bony prickles standing out on every side. If we could conceive a turnip stuck full of pins on every side, and running upon these pins with some degree of swiftness, we should have some idea of this extraordinary creature. The mouth is placed downwards; the vent is above; the shell is a hollow vase, resembling a scooped apple; and this filled with a soft muscular substance, through which the intestines wind from the bottom to the top. The mouth, which is placed undermost, is large and red, furnished with five sharp teeth, which are easily discerned. The jaws are strengthened by five small bones, in the centre of which is a small fleshy tongue; and from this the intestines make a winding of five spires, round the internal sides of the shell, ending at the top,

where the excrements are excluded. But what makes the most extraordinary part of this animal's confirmation, are its horns, and its spines, that point from every part of the body, like the horns of a snail, and that serve at once as legs to move upon, as arms to feel with, and as instruments of capture and defence. Between their horns it has also spines that are not endowed with such a share of motion. The spines and the horns issue from every part of the body, the spines being hard and prickly, the horns being softer, longer than the spines, and never seen except in the water. They are put forward and withdrawn like the horns of a snail, and are hid at the base of the spine, serving as was said before, for procuring food and motion. All this apparatus, however, is only seen when the animal is hunting his prey at the bottom of the water; for a few minutes after it is taken, all the horns are withdrawn into the body, and most of the spines drop off.

It is generally said of insects, that those which have the greatest number of legs, always move the slowest; but this animal seems to be an exception to the rule; for though furnished with two thousand spines, and twelve hundred horns, all serving for legs, and which from their number seem to impede each other's motion, yet it runs with some share of swiftness at the bottom, and it is sometimes no easy matter to overtake it.

Very different in motion, though not much different in shape from them, are the Acorn Shell-fish, the Thumb-footed Shell-fish, and the Imaginary Barnacle. These are fixed to one spot, and appear to vegetate from a stalk. Indeed, to an inattentive spectator, each actually seems to be a kind of fungus that grows in the deep, destitute of animal life, as well as motion. But the enquirer will soon change his opinion, when he comes to observe this mushroom-like figure more minutely. He will then see that the animal residing within the shell, has not only life, but some degree of

voraciousness ; that it has a cover, by which it opens and shuts its shell at pleasure ; that it has twelve large crooked arms, furnished with air, which it thrusts forth for its prey ; and eight smaller, which are generally kept in the shell. They are seen adhering to every substance that is to be met with in the ocean ; rocks, roots of trees, ships bottoms, whales, lobsters, and even crabs ; like bunches of grapes clung to each other. It is amusing enough to behold their operations. They for some time remain motionless within their shell ; but when the sea is calm, they are seen opening the lid, and peeping about them. They then thrust out their long neck, look round them for some time, and then abruptly retreat back into their box, shut the lid, and lurk in darkness and security.

Among the shell-fish on the Waterford coast, is the Murex, which gave the Tyrian purple. It is in great plenty there, and is by the English called a horse-winkle. The shell is about an inch long, and half an inch broad, and turns spirally like a snail-shell. Each fish has a peculiar reservoir, which contains a large drop of liquor : if this is pressed out on linen, the linen first appears of a dirty yellow, inclining to green, afterward it changes to a lemon colour, then to a deep green ; then it turns to a deep blue, and at last to a charming purple.

The shells of the ancient purple-fish, are still common on the Tyrian shore. The fish itself is found in great abundance in the seas of the Spanish West-Indies, near Panama and Nicoya, exactly agreeing with Pliny's account of the ancient Murex. Cloth of Segovia, dyed with this purple, is sold for twenty crowns an ell, and is very rarely worn by any, but the greatest noblemen in Spain. The Caribbee islands have also the same sort of fish, which we may likewise find nearer home, namely on the coasts of Somersetshire, as well as of South-Wales.

The pearl muscles lie partly open : the inside of the shell is of a pearly colour. The pearl lies in the smaller end of it, at the extremity of the gut, and out of the body of the fish, between the two films that line the shell. This answers to the stone in other animals, increasing by crusts growing over one another. Accordingly if a pearl be pinched in a vice, the upper coat will crack and leap away. And as it is now known, that the shells of fishes are formed of stony matter oozing out of their body, it is no wonder if that matter when it chances to overflow, bursts forth in any cavity of the body, and forms a little mass, which hardening, becomes a pearl of the same colour with the shell.

Whereas all other animals take in nutriment by the mouth, the muscle takes it in by the anus. The part called the head though without eyes, ears, or tongue, is immovably fastened to one of the shells, so that it cannot receive any thing. The food of a muscle is water, which as the shell opens, enters in at the anus, and passing on by certain canals running between the shell and the animal, is thence conveyed into the mouth.

We have lately discovered a progressive motion in those shell-fish, which were supposed to be quite fixed. Even oysters, which one would think wholly immovable, if they are thrown irregularly into a vessel of water, will in a while turn themselves till the smooth shell becomes uppermost : otherwise they could hold no water in the concave shell for their sustenance.

Muscles can walk on the ground, which they do in this manner. Lying on the flat side of their shell, they thrust out a part, in form of a tongue, wherewith they make little motions to the right and left, and thereby dig a passage in the sand. In this digging they drop gradually on one side, and so get the shell mounted on its edge ; then they stretch out the tongue as far as they can, and rest for a minute or two on

its extremity to draw the shell after them, as water-snails do. This motion is repeated as long as they please; thus they form a sort of groove in the sand, which sustains the shell on either side, and leaves behind them a sort of irregular tract, three or four yards long. In rivers abounding with muscles one may see many of them, with a muscle at the end of each.

That called the arm or a leg in a sea-muscle, which in its natural state is not above two lines long, may reach out of the shell two inches: and the muscle having laid hold on a fixed point therewith, bends and shortens it and so drags itself on. The beard serves for an anchor to fasten it to some heavy body, that it may not be carried away with the motion of the waves.

When a pond muscle walks, it thrusts out its whole belly, in form of the keel of a ship, and creeps on the belly as the serpent does. So true it is, that nature is not confined in her manner of operation, but is every varying, though never confused.

In Port-Mahon harbour, there are stones from half a hundred to five hundred weight each, lying at all depths, full of shells, each containing a single fish of the muscle-kind. The holes in the surface are far narrower than the hole in which is the fish, which it seems is capable of enlarging its room as it grows bigger, by abraising the sides of its cells. And this is apparent, from the sandy matter found in the bottom of those cells, whenever the orifice is higher than the bottom; for then the fish cannot throw it out.

The Bollani likewise in the Adriatic sea, live in large stones. Their shell is rough and oblong, not unlike a date. They are found in several kinds of porous stones. In the pores of these the spawn is deposited. Frequently the aperture, through which it was injected, is no longer perceivable; but the fish thrives

notwithstanding. On breaking some of these stones, one finds near thirty live fish, though no opening can be perceived on the outside. Each has just room to open its shell, the inside of which is white, the outside ash-colour ; the largest is four or five inches long. Both the fish itself and its juices are so luminous, one may see to read by it ; and even water in which it has been squeezed, put into a glass, will shine ten or twelve hours.

Likewise in Toulon harbour are found solid stones containing in separate cells, secluded from all communication with the air, several living shell-fish. The same are found along the coast of Alcona, in stones weighing fifty pounds and upwards. The outside of which is soft, but the inside so hard as to require an iron mallet, and a strong arm to break them.

Pholades Bollani, when divested of their shells, resemble a roundish, soft pudding, with no instrument that seems in the least fitted for boring into stones, or even penetrating the softest substance. A pholade is furnished with two teeth indeed ; but these are placed in such a situation as to be incapable of touching the hollow surface of its stony dwelling. It has also two covers to its shell that open and shut at either end ; but these are totally unserviceable to it as a miner. The instrument with which it performs all its operations, and buries itself in the hardest rocks, is only a broad fleshy substance, somewhat resembling a tongue, that is seen issuing from the bottom of its shell. With this soft yielding instrument, it perforates the most solid marbles ; and having, while little and young, made its way, by a very narrow passage into the substance of the stone, it then begins to grow bigger, and thus to enlarge its apartment. While yet naked and very small, it has effected an entrance, and has buried its body in the stone : it there continues for life at its ease ; the sea-water that enters at its apertures supplying it with luxurious plenty. When

the animal has taken too great a quantity of water, it is seen to spurt it out of its hole with some violence. Upon this seemingly thin diet, it quickly grows larger, and soon finds itself under a necessity of enlarging its habitation and its shell. The motion of the pholas is slow beyond conception ; its progress keeps pace with the growth of its body ; and in proportion as it grows larger, it makes its way farther into the rock. When it has got a certain way in, it then turns from a certain direction, and hollows downward ; till at last when its habitation is completed, the whole apartment resembles the bowl of a tobacco-pipe: the hole is the shank, being that by which the animal entered.

Thus immured, the pholas lives in darkness, indolence, and plenty ; it never removes from the narrow mansion into which it has penetrated ; and seems perfectly content with being enclosed in its own sepulchre. The influx of the sea-water, that enters by its little gallery, satisfies all its wants ; and without any other food, it is found to grow from seven to eight inches long, and thick in proportion.

Yet the pholas thus shut up is not so solitary an animal as it would at first appear ; for though it is immured in its hole without egress ; though it is impossible for the animal, grown to a great size, to get out by the way it made in, yet many of this kind meet in the heart of the rock, and like miners in a siege, who sometimes cross each others galleries, they frequently break in upon each others retreats : whether their thus meeting be the work of accident or of choice, few can take upon them to determine ; certain it is they are most commonly found in numbers in the same rock ; and sometimes above twenty are discovered within a few inches of each other.

As to the nest, this animal is found in greatest number at Ancona in Italy ; it is found along the shores of Normandy and Poitou, in France ; it is found also upon some of the coasts of Scotland, and in ge-

neral is considered as a very great delicacy at the tables of the luxurious.

One of the most extraordinary kinds of shell-fish is the Animal-flower, in Barbadoes. In the parish of St. Lucy, on the north-side of the island, there is a high rocky cliff fronting the sea, near the bottom of which is a large cave. This opens into another cave, the bottom of which is a bason of water. In the midst of this bason is a rock, always covered with water: on the sides of which, a few inches below the water, are seen at all times of the year, issuing out of little holes, what have the appearance of finely radiated flowers, in size, colour and shape greatly resembling a common marygold.

If you attempt to pluck one of these, as soon as your fingers come within two or three inches of it, it contracts, closes up its border, and shrinks back into the hole of the rock. But if left undisturbed for a few minutes, it issues again and soon appears in full bloom. This might induce one to believe, that it was no other than an aquatic sensitive plant.

But on a nearer inspection we may discern four dark-coloured filaments, rising from the centre, moving with a quick and spontaneous motion, and frequently closing, to seize its prey, much like the claws of a lobster. So that the seeming flower is really an animal; and its body, which appeared to be the stalk of the flower is black, about as big as a raven's quill.

It seems the vivid yellow colour of its feelers, is absolutely necessary to procure its food. The water in the cave having no motion, cannot bring any food to them. Therefore the Creator has endued this creature with a quality which may allure its prey. For bright colours invite many aquatic animals, as the flame of a candle does flies.

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