NATURAL THEOLOGY.

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NATURAL THEOLOGY.

CHAPTER I.

STATE OF THE ARGUMENT.

In crossing a heath, suppose I pitched my foot against a *stone*, and were asked how the stone came to be there, I might possibly answer, that, for any thing I knew to the contrary, it had lain there for ever; nor would it, perhaps, be very easy to show the absurdity of this answer. But suppose I had found a *watch* upon the ground, and it should be inquired how the watch happened to be in that place, I should hardly think of the answer which I had before given—that, for any thing I knew, the watch might have always been there. Yet why should not this answer serve for the watch as well as for the stone? why is it not as admissible in the second case as in the first? For this reason, and for no other, viz. that, when we come to inspect the watch, we perceive (what we could not discover in the stone) that its several parts are framed and put together for a purpose, *e. g.* that they are so formed and adjusted as to produce motion, and that motion so regulated as to point out the hour of the day; that, if the different parts had been differently shaped from what they are, or placed after any other manner, or in any other order than that in which they are placed, either no motion at all would have been carried on in the machine, or none which would have answered the use that is now served by it. To reckon up a few of the plainest of these parts, and of their offices, all tending to one result:—We see a cylindrical box containing a coiled elastic spring, which, by its endeavor to relax itself, turns round the box. We next observe a flexible chain (artificially wrought for the sake of flexure) communicating the action of the spring from the box to the fusee. We then find a series of wheels, the teeth of which catch in, and apply to, each other, conducting the motion from the fusee to the balance, and from the balance to the pointer, and, at the same time, by the size and shape of those wheels, so regulating that motion as to terminate in causing an index, by an equable and measured progression, to pass over a given space in a given time. We take notice that the wheels are made of brass, in order to keep them from rust; the springs of steel, no other metal being so elastic; that over the face of the watch there is placed a glass, a material employed in no other part of the work, but in the room of which, if there had been any other than a transparent substance, the hour could not be seen without opening the case. This mechanism being observed, (it requires indeed an examination of the instrument, and perhaps some previous knowledge of the subject, to perceive and understand it; but being once, as we have said, observed and understood,) the inference, we think, is inevitable, that the watch must have had a maker; that there must have existed, at some time, and at some place or other, an artificer or artificers who formed it for the purpose which we find it actually to answer; who comprehended its construction, and designed its use.

I. Nor would it, I apprehend, weaken the conclusion, that we had never seen a watch made; that we had never known an artist capable of making one; that we were altogether incapable of executing such a piece of workmanship ourselves, or of understanding in what manner it was performed; all this being no more than what is true of some exquisite remains of ancient art, of some lost arts, and, to the generality of mankind, of the more curious productions of modern manufacture. Does one man in a million know how oval frames are turned? Ignorance of this kind exalts our opinion of the unseen and unknown artist's skill, if he be unseen and unknown, but raises no doubt in our minds of the existence and agency of such an artist, at some former time, and in some place or other. Nor can I perceive that it varies at all the inference, whether the question arise concerning a human agent, or concerning an agent of a different species, or an agent possessing, in some respect, a different nature.

II. Neither, secondly, would it invalidate our conclusion, that the watch sometimes went wrong, or that it seldom went exactly right. The purpose of the machinery, the design, and the designer, might be evident, and, in the case supposed, would be evident, in whatever way we accounted for the irregularity of the movement, or whether we could account for it or not. It is not necessary that a machine be perfect, in order to show with what design it was made: still less necessary, where the only question is, whether it were made with any design at all.

III. Nor, thirdly, would it bring any uncertainty into the argument, if there were a few parts of the watch, concerning which we could not discover, or had not yet discovered, in what manner they conduced to the general effect; or even some parts, concerning which we could not ascertain whether they conduced to that effect in any manner whatever. For, as to the first branch of the case, if by the loss, or disorder, or decay of the parts in question, the movement of the watch were found in fact to be stopped, or disturbed, or retarded, no doubt would remain in our minds as to the utility or intention of these parts, although we should be unable to investigate the manner according to which, or the connexion by which, the ultimate effect depended upon their action or assistance; and the more complex is the machine, the more likely is this obscurity to arise. Then, as to the second thing supposed, namely, that there were parts which might be spared without prejudice to the movement of the watch, and that he had proved this by experiment, these superfluous parts, even if we were completely assured that they were such, would not vacate the reasoning which we had instituted concerning other parts. The indication of contrivance remained, with respect to them, nearly as it was before.

IV. Nor, fourthly, would any man in his senses think the existence of the watch, with its various machinery, accounted for, by being told that it was one out of possible combinations of material forms; that whatever he had found in the place where he found the watch, must have contained some internal configuration or other; and that this configuration might be the structure now exhibited, viz. of the works of a watch, as well as a different structure.

V. Nor, fifthly, would it yield his inquiry more satisfaction, to be answered, that there existed in things a principle of order, which had disposed the parts of the watch into their present form and situation. He never knew a watch made by the principle of order; nor can he even form to himself an idea of what is meant by a principle of order, distinct from the intelligence of the watchmaker.

VI. Sixthly, he would be surprised to hear that the mechanism of the watch was no proof of contrivance, only a motive to induce the mind to think so:

VII. And not less surprised to be informed, that the watch in his hand was nothing more than the result of the laws of *metallic* nature. It is a perversion of language to assign any law as the efficient, operative cause of any thing. A law presupposes an agent; for it is only the mode according to which an agent proceeds: it implies a power; for it is the order according to which that power acts. Without this agent, without this power, which are both distinct from itself, the *law* does nothing, is nothing. The expression, "the law of metallic nature," may sound strange and harsh to a philosophic ear; but it seems quite as justifiable as some others which are more familiar to him, such as "the law of vegetable nature," "the law of animal nature," or, indeed, as "the law of nature" in general, when assigned as the cause of phenomena, in exclusion of agency and power, or when it is substituted into the place of these.

VIII. Neither, lastly, would our observer be driven out of his conclusion, or from his confidence in its truth, by being told that he knew nothing at all about the matter. He knows enough for his argument: he knows the utility of the end: he knows the subserviency and adaptation of the means to the end. These points being known, his ignorance of other points, his doubts concerning other points, affect not the certainty of his reasoning. The consciousness of knowing little need not beget a distrust of that which he does know.

CHAPTER II.

STATE OF THE ARGUMENT CONTINUED.

Suppose, in the next place, that the person who found the watch should, after some time, discover that, in addition to all the properties which he had hitherto observed in it, it possessed the unexpected property of producing, in the course of its movement, another watch like itself (the thing is conceivable;) that it contained within it a mechanism, a system of parts, a mould, for instance, or a complex adjustment of lathes, files, and other tools, evidently and separately calculated for this purpose; let us inquire what effect ought such a discovery to have upon his former conclusion.

I. The first effect would be to increase his admiration of the contrivance, and his conviction of the consummate skill of the contriver. Whether he regarded the object of the contrivance, the distinct apparatus, the intricate, yet in many parts intelligible mechanism by which it was carried on, he would perceive, in this new observation, nothing but an additional reason for doing what he had already done—for referring the construction of the watch to design, and to supreme art. If that construction *without* this property, or which is the same thing, before this property had been noticed, proved intention and art to have been employed about it, still more strong would the proof appear, when he came to the knowledge of this further property, the crown and perfection of all the rest.

II. He would reflect, that though the watch before him were, *in some sense*, the maker of the watch which was fabricated in the course of its movements, yet it was in a very different sense from that in which a carpenter, for instance, is the maker of a chair—the author of its contrivance, the cause of the relation of its parts to their use. With respect to these, the first watch was no cause at all to the second; in no such sense as this was it the author of the constitution and order, either of the parts which the new watch contained, or of the parts by the aid and instrumentality of which it was produced. We might possibly say, but with great latitude of expression, that a stream of water ground corn; but no latitude of expression would allow us to say, no stretch of conjecture could lead us to think, that the stream of water built the mill, though it were too ancient for us to know who the builder was. What the stream of water does in the affair is neither more nor less than this; by the application of an unintelligent impulse to a mechanism previously arranged, arranged independently of it, and arranged by intelligence, an effect is produced, viz. the corn is ground. But the effect results from the arrangement. The force of the stream cannot be said to be the cause or the author of the effect, still less of the arrangement. Understanding and plan in the formation of the mill were not the less necessary for any share which the water has in grinding the corn; yet is this share the same as that which the watch would have contributed to the production of the new watch, upon the supposition assumed in the last section. Therefore,

III. Though it be now no longer probable that the individual watch which our observer had found was made immediately by the hand of an artificer, yet doth not this alteration in anywise affect the inference, that an artificer had been originally employed and concerned in the production. The argument from design remains as it was. Marks of design and contrivance are no more accounted for now than they were before. In the same thing, we may ask for the cause of different properties.

We may ask for the cause of the color of a body, of its hardness, of its heat; and these causes may be all different. We are now asking for the cause of that subserviency to a use, that relation to an end, which we have remarked in the watch before us. No answer is given to this question, by telling us that a preceding watch produced it. There cannot be design without a designer; contrivance, without a contriver; order, without choice; arrangement, without any thing capable of arranging; subserviency and relation to a purpose, without that which could intend a purpose; means suitable to an end, and executing their office in accomplishing that end, without the end ever having been contemplated, or the means accommodated to it. Arrangement, disposition of parts, subserviency of means to an end, relation of instruments to a use, imply the presence of intelligence and mind. No one, therefore, can rationally believe that the insensible, inanimate watch, from which the watch before us issued, was the proper cause of the mechanism we so much admire in it—could be truly said to have constructed the instrument, disposed its parts, assigned their office, determined their order, action, and mutual dependency, combined their several motions into one result, and that also a result connected with the utilities of other beings. All these properties, therefore, are as much unaccounted for as they were before.

IV. Nor is any thing gained by running the difficulty farther back, *i. e.* by supposing the watch before us to have been produced from another watch, that from a former, and so on indefinitely. Our going back ever so far, brings us no nearer to the least degree of satisfaction upon the subject. Contrivance is still unaccounted for. We still want a contriver. A designing mind is neither supplied by this supposition nor dispensed with. If the difficulty were diminished the farther we went back, by going back indefinitely we might exhaust it. And this is the only case to which this sort of reasoning applies. Where there is a tendency, or, as we increase the number of terms, a continual approach towards a limit, *there*, by supposing the number of terms to be what is called infinite, we may conceive the limit to be attained; but where there is no such tendency or approach, nothing is effected by lengthening the series. There is no difference as to the point in question, (whatever there may be as to many points,) between one series and another; between a series which is finite, and a series which is infinite. A chain, composed of an infinite number of links, can no more support itself than a chain composed of a finite number of links. And of this we are assured; (though we never *can* have tried the experiment,) because, by increasing the number of links, from ten, for instance, to a hundred, from a hundred to a thousand, &c. we make not the smallest approach, we observe not the smallest tendency towards self-support. There is no difference in this respect (yet there may be a great difference in several respects) between a chain of a greater or less length, between one chain and another, between one that is finite and one that is infinite. This very much resembles the case before us. The machine which we are inspecting demonstrates, by its construction, contrivance and design. Contrivance must have had a contriver; design, a designer; whether the machine immediately proceeded from another machine or not. That circumstance alters not the case. That other machine may, in like manner, have proceeded from a former machine: nor does that alter the case; the contrivance must have had a contriver. That former one from one preceding it: no alteration still; a contriver is still necessary. No tendency is perceived, no approach towards a diminution of this necessity. It is the same with any and every succession of these machines; a succession of ten, of a hundred, of a thousand; with one series, as with another; a series which is finite, as with a series which is infinite. In whatever other respects they may differ, in this they do not. In all, equally, contrivance and design are unaccounted for.

The question is not simply, How came the first watch into existence, which question, it may be pretended, is done away by supposing the series of watches thus produced from one another to have been infinite, and consequently to have had no such *first*, for which it was necessary to provide a cause. This, perhaps, would have been nearly the state of the question, if nothing had been before us but an unorganized, unmechanized substance, without mark or indication of contrivance. It might be difficult to show that such substance could not have existed from eternity, either in succession (if it were possible, which I think it is not, for unorganized bodies to spring from one another,) or by individual perpetuity. But that is not the question now. To suppose it to be so, is to suppose that it made no difference whether he had found a watch or a stone. As it is, the metaphysics of that question have no place: for, in the watch which we are examining, are seen contrivance, design; an end, a purpose; means for the end, adaptation to the purpose. And the question which irresistibly presses upon our thoughts is, Whence this contrivance and design? The thing required is the intending mind, the adapted hand, the intelligence by which that hand was directed. This question, this demand, is not shaken off, by increasing a number or succession of substances, destitute of these properties; nor the more, by increasing that number to infinity. If it be said, that, upon the supposition of one watch being produced from another in the course of that other's movements, and by means of the mechanism within it, we have a cause for the watch in my hand, viz. the watch from which it proceeded,—I deny, that for the design, the contrivance, the suitableness of means to an end, the adaptation of instruments to a use, (all of which we discover in the watch,) we have any cause whatever. It is in vain, therefore, to assign a series of such causes, or to allege that a series may be carried back to infinity; for I do not admit that we have yet any cause at all for the phenomena, still less any series of causes either finite or infinite. Here is contrivance, but no contriver; proofs of design, but no designer.

V. Our observer would further also reflect, that the maker of the watch before him was, in truth and reality, the maker of every watch produced from it: there being no difference (except that the latter manifests a more exquisite skill) between the making of another watch with his own hands, by the mediation of files, lathes, chisels, &c. and the disposing, fixing, and inserting of these instruments, or of others equivalent to them, in the body of the watch already made, in such a manner as to form a new watch in the course of the movements which he had given to the old one. It is only working by one set of tools instead of another.

The conclusion which the *first* examination of
ıe watch, of its works, construction, and move-
ıent, suggested, was, that it must have had, for
ause and author of that construction, an artificer
ho understood its mechanism and designed its
se. This conclusion is invincible. A *second* ex-
mination presents us with a new discovery. The
atch is found, in the course of its movement, to
roduce another watch similar to itself; and not
ıly so, but we perceive in it a system, or organi-
ıtion, separately calculated for that purpose.
Vhat effect would this discovery have, or ought
to have, upon our former inference? What, as
ath already been said, but to increase, beyond
ıeasure, our admiration of the skill which had
een employed in the formation of such a ma-
ıine? Or shall it, instead of this, all at once turn
s round to an opposite conclusion, viz. that no art
skill whatever has been concerned in the busi-
ess, although all other evidences of art and skill
main as they were, and this last and supreme
iece of art be now added to the rest? Can this
e maintained without absurdity? Yet this is
heism.

CHAPTER III.

APPLICATION OF THE ARGUMENT.

This is atheism: for every indication of contrivance, every manifestation of design, which existed in the watch, exists in the works of nature; with the difference, on the side of nature, of being greater and more, and that in a degree which exceeds all computation. I mean that the contrivances of nature surpass the contrivances of art, in the complexity, subtilty, and curiosity of the mechanism; and still more, if possible, do they go beyond them in number and variety; yet in a multitude of cases, are not less evidently mechanical, not less evidently contrivances, not less evidently accommodated to their end, or suited to their office, than are the most perfect productions of human ingenuity.

I know no better method of introducing so large a subject, than that of comparing a single thing with a single thing: an eye, for example, with a telescope. As far as the examination of the instrument goes, there is precisely the same proof that the eye was made for vision, as there is that the telescope was made for assisting it. They are made upon the same principles; both being adjusted to the laws by which the transmission and refraction of rays of light are regulated. I speak not of the origin of the laws themselves; but such laws being fixed, the construction in both cases is adapted to them. For instance; these laws require, in order to produce the same effect, that the rays of light, in passing from water into the eye, should be refracted by a more convex surface than when it passes out of air into the eye. Accordingly we find that the eye of a fish, in that part of it called the crystalline lens, is much rounder than the eye of terrestrial animals. What plainer manifestation of design can there be in this difference? What could a mathematical instrument maker have done more to show his knowledge of his principle, his application of that knowledge, his suiting of his means to his end; I will not say to display the compass or excellence of his skill and art, for in these all comparison is indecorous, but to testify council, choice, consideration, purpose?

To some it may appear a difference sufficient to destroy all similitude between the eye and the telescope, that the one is a perceiving organ, the other an unperceiving instrument. The fact is that they are both instruments. And as to the mechanism, at least as to mechanism being employed, and even as to the kind of it, this circumstance varies not the analogy at all. For observe what the constitution of the eye is. It is necessary, in order to produce distinct vision, that an image or picture of the object be formed at the bottom of the eye. Whence this necessity arises, or how th picture is connected with the sensation, or con-tributes to it, it may be difficult, nay, we will con-fess, if you please, impossible for us to search out But the present question is not concerned in th inquiry. It may be true, that, in this, and in othe instances, we trace mechanical contrivance a cer-tain way; and that then we come to somethin which is not mechanical, or which is inscrutable But this affects not the certainty of our investiga-tion, as far as we have gone. The difference be-tween an animal and an automatic statue consist in this,—that, in the animal, we trace the mecha-nism to a certain point, and then we are stopped either the mechanism being too subtile for ou discernment, or something else beside the know laws of mechanism taking place; whereas, in th automaton, for the comparatively few motions o which it is capable, we trace the mechanism throughout. But, up to the limit, the reasoning i as clear and certain in the one case as in th other. In the example before us, it is a matter o certainty, because it is a matter which experienc and observation demonstrate, that the formatio of an image at the bottom of the eye is necessar to perfect vision. The image itself can be shown Whatever affects the distinctness of the image, af-fects the distinctness of the vision. The formatio then of such an image being necessary (no matte how) to the sense of sight, and to the exercise of that sense, the apparatus by which it is formed is constructed and put together, not only with infinitely more art, but upon the self-same principles of art, as in the telescope or the camera-obscura. The perception arising from the image may be laid out of the question; for the production of the image, these are instruments of the same kind. The end is the same; the means are the same. The purpose in both is alike; the contrivance for accomplishing that purpose is in both alike. The lenses of the telescopes, and the humors of the eye, bear a complete resemblance to one another, in their figure, their position, and in their power over the rays of light, viz. in bringing each pencil to a point at the right distance from the lens; namely, in the eye, at the exact place where the membrane is spread to receive it. How is it possible, under circumstances of such close affinity, and under the operation of equal evidence, to exclude contrivance from the one; yet to acknowledge the proof of contrivance having been employed, as the plainest and clearest of all propositions, in the other?

The resemblance between the two cases is still more accurate, and obtains in more points than we have yet represented, or than we are, on the first view of the subject, aware of. In dioptric telescopes there is an imperfection of this nature.

Pencils of light, in passing through glass lenses, are separated into different colors, thereby tinging the object, especially the edges of it, as if it were viewed through a prism. To correct this inconvenience had been long a desideratum in the art. At last it came into the mind of a sagacious optician, to inquire how this matter was managed in the eye: in which there was exactly the same difficulty to contend with as in the telescope. His observation taught him, that, in the eye, the evil was cured by combining lenses composed of different substances, *i. e.* of substances which possessed different refracting powers. Our artist borrowed thence his hint; and produced a correction of the defect by imitating, in glasses made from different materials, the effects of the different humors through which the rays of light pass before they reach the bottom of the eye. Could this be in the eye without purpose, which suggested to the optician the only effectual means of attaining that purpose?

But further; there are other points, not so much perhaps of strict resemblance between the two, as of superiority of the eye over the telescope; yet of a superiority which, being founded in the laws that regulate both, may furnish topics of fair and just comparison. Two things were wanted to the eye, which were not wanted (at least in the same degree) to the telescope; and these were the adaptation of the organ, first, to different degrees of light; and secondly, to the vast diversity of distance at which objects are viewed by the naked eye, viz. from a few inches to as many miles. These difficulties present not themselves to the maker of the telescope. He wants all the light he can get; and he never directs his instrument to objects near at hand. In the eye, both these cases were to be provided for; and for the purpose of providing for them, a subtile and appropriate mechanism is introduced.

I. In order to exclude excess of light, when it is excessive, and to render objects visible under obscurer degrees of it, when no more can be had, the hole or aperture in the eye, through which the light enters, is so formed as to contract or dilate itself for the purpose of admitting a greater or less number of rays at the same time. The chamber of the eye is a camera-obscura, which, when the light is too small, can enlarge its opening; when too strong, can again contract it; and that without any other assistance than that of its own exquisite machinery. It is farther also, in the human subject, to be observed, that this hole in the eye, which we call the pupil, under all its different dimensions, retains its exact circular shape. This is a structure extremely artificial. Let an artist only try to execute the same; he will find that his threads and strings must be disposed with great consideration and contrivance, to make a circle which shall continually change its diameter yet preserve its form. This is done in the eye by an application of fibres, *i. e.* of strings similar, in their position and action, to what an artist would and must employ, if he had the same piece of workmanship to perform.

II. The second difficulty which has been stated was the suiting of the same organ to the perception of objects that lie near at hand, within a few inches, we will suppose, of the eye, and of objects which are placed at a considerable distance from it, that, for example, of as many furlongs, (I speak in both cases of the distance at which distinct vision can be exercised.) Now this, according to the principles of optics, that is, according to the laws by which the transmission of light is regulated (and these laws are fixed) could not be done without the organ itself undergoing an alteration, and receiving an adjustment, that might correspond with the exigency of the case, that is to say, with the different inclination to one another under which the rays of light reached it. Rays issuing from points placed at a small distance from the eye, and which consequently must enter the eye in a spreading or diverging order, cannot, by the same optical instrument in the same state, be brought to a point, *i. e.* be made to form an image, in the same place, with rays proceeding from objects situated at a much greater distance, and which rays arrive at the eye in directions nearly (and physically speaking) parallel. It requires a rounder lens to do it. The point of concourse behind the lens must fall critically upon the retina, or the vision is confused; yet, other things remaining the same, this point, by the immutable properties of light, is carried further back when the rays proceed from a near object than when they are sent from one that is remote. A person who was using an optical instrument would manage this matter by changing, as the occasion required, his lens or his telescope, or by adjusting the distance of his glasses with his hand or his screw: but how is this to be managed in the eye? What the alteration was, or in what part of the eye it took place, or by what means it was effected, (for if the known laws which govern the refraction of light be maintained, some alteration in the state of the organ there must be,) had long formed a subject of inquiry and conjecture. The change, though sufficient for the purpose, is so minute as to elude ordinary observation. Some very late discoveries, deduced from a laborious and most accurate inspection of the structure and operation of the organ, seem at length to have ascertained the mechanical alteration which the parts of the eye undergo. It is found, that by the action of certain muscles, called the straight muscles, and which action is the most advantageous that could be imagined for the purpose, it is found, I say, that whenever the eye is directed to a near object, three changes are produced in it at the same time, all severally contributing to the adjustment required. The cornea, or outermost coat of the eye, is rendered more round and prominent; the crystalline lens underneath is pushed forward; and the axis of vision, as the depth of the eye is called, is elongated. These changes in the eye vary its power over the rays of light in such a manner and degree as to produce exactly the effect which is wanted, viz. the formation of an image *upon the retina*, whether the rays come to the eye in a state of divergency, which is the case when the object is near to the eye, or come parallel to one another, which is the case when the object is placed at a distance. Can any thing be more decisive of contrivance than this is? The most secret laws of optics must have been known to the author of a structure endowed with such a capacity of change. It is as though an optician, when he had a nearer object to view, should rectify his instrument by putting in another glass, at the same time drawing out also his tube to a different length.

Observe a new-born child first lifting up its eyelids. What does the opening of the curtain discover? The anterior part of two pellucid globes, which, when they come to be examined, are found to be constructed upon strict optical principles; the self-same principles upon which we ourselves construct optical instruments. We find them perfect for the purpose of forming an image by refraction; composed of parts executing different offices; one part having fulfilled its office upon the pencil of light, delivering it over to the action of another part; that to a third, and so onward: the progressive action depending for its success upon the nicest and minutest adjustment of the parts concerned: yet these parts so in fact adjusted as to produce, not by a simple action or effect, but by a combination of actions and effects, the result which is ultimately wanted. And forasmuch as this organ would have to operate under different circumstances, with strong degrees of light and with weak degrees, upon near objects and upon remote ones, and these differences demanded, according to the laws by which the transmission of light is regulated, a corresponding diversity of structure,—that the aperture, for example, through which the light passes should be larger or less—the lenses rounder or flatter—or that their distance from the tablet upon which the picture is delineated should be shortened or lengthened,—this, I say, being the case, and the difficulty to which the eye was to be adapted, we find its several parts capable of being occasionally changed, and a most artificial apparatus provided to produce that change. This is far beyond the common regulator of a watch, which requires the touch of a foreign hand to set it; but it is not altogether unlike Harrison's contrivance for making a watch regulate itself, by inserting within it a machinery which, by the artful use of the different expansion of metals, preserves the equability of the motion under all the various temperatures of heat and cold in which the instrument may happen to be placed. The ingenuity of this last contrivance has been justly praised. Shall, therefore, a structure which differs from it chiefly by surpassing it, be accounted no contrivance at all? or, if it be a contrivance, that it is without a contriver?

But this, though much, is not the whole: by different species of animals the faculty we are describing is possessed in degrees suited to the different range of vision which their mode of life and of procuring their food requires. *Birds*, for instance, in general, procure their food by means of their beak; and, the distance between the eye and the point of the beak being small, it becomes necessary that they should have the power of seeing very near objects distinctly. On the other hand, from being often elevated much above the ground, living in the air, and moving through it with great velocity, they require for their safety, as well as for assisting them in descrying their prey, a power of seeing at a great distance; a power of which, in birds of rapine, surprising examples are given. The fact accordingly is, that two peculiarities are found in the eyes of birds, both tending to *facilitate* the change upon which the adjustment of the eye to different distances depends. The one is a bony, yet, in most species, a flexible rim or hoop, surrounding the broadest part of the eye, which confining the action of the muscles to that part, increases the effect of their lateral pressure upon the orb, by which pressure its axis is elongated for the purpose of looking at very near objects. The other is an additional muscle, called the marsupium, to draw, on occasion, the crystalline lens *back*, and to fit the same eye for the viewing of very distant objects. By these means, the eyes of birds can pass from one extreme to another of their scale of adjustment, with more ease and readiness than the eyes of other animals.

The eyes of *fishes* also, compared with those of terrestrial animals, exhibit certain distinctions of structure, adapted to their state and element. We have already observed upon the figure of the crystalline compensating by its roundness the density of the medium through which their light passes. To which we have to add, that the eyes of fish, in their natural and indolent state, appear to be adjusted to near objects, in this respect differing from the human eye, as well as those of quadrupeds and birds. The ordinary shape of the fish's eye being in a much higher degree convex than that of land animals, a corresponding difference attends its muscular conformation, viz. that it is throughout calculated for *flattening* the eye.

The *iris* also in the eyes of fish does not admit of contraction. This is a great difference, of which the probable reason is, that the diminished light in water is never too strong for the retina.

In the *eel*, which has to work its head through sand and gravel, the roughest and harshest substances, there is placed before the eye, and at some distance from it, a transparent, horny, convex case or covering, which, without obstructing the sight, defends the organ. To such an animal could any thing be more wanted or more useful?

Thus, in comparing the eyes of different kinds of animals, we see in their resemblances and distinctions one general plan laid down, and that plan varied with the varying exigencies to which it is to be applied.

There is one property, however, common, I believe, to all eyes, at least to all which have been examined,* namely, that the optic nerve enters the bottom of the eye, not in the centre or middle, but a little on one side: not in the point where the axis

* The eye of the seal or sea-calf, I understand, is an exception. Mem. Acad. Paris, 1710, p. 123.

of the eye meets the retina, but between that point and the nose. The difference which this makes is, that no part of an object is unperceived by both eyes at the same time.

In considering vision as achieved by the means of an image formed at the bottom of the eye, we can never reflect without wonder upon the smallness yet correctness of the picture, the subtilty of the touch, the fineness of the lines. A landscape of five or six square leagues is brought into a space of half an inch diameter; yet the multitude of objects which it contains are all preserved, are all discriminated in their magnitudes, positions, figures, colors. The prospect from Hampstead-hill is compressed into the compass of a sixpence, yet circumstantially represented. A stage-coach, travelling at an ordinary speed for half an hour, passes, in the eye, only over one-twelfth of an inch, yet is this change of place in the image distinctly perceived throughout its whole progress; for it is only by means of that perception that the motion of the coach itself is made sensible to the eye. If any thing can abate our admiration of the smallness of the visual tablet compared with the extent of vision, it is a reflection which the view of nature leads us every hour to make, viz. that, in the hands of the Creator, great and little are nothing.

Sturmius held, that the examination of the eye was a cure for atheism. Besides that conformity to optical principles which its internal constitution displays, and which alone amounts to a manifestation of intelligence having been exerted in the structure; besides this, which forms, no doubt, the leading character of the organ, there is to be seen, in every thing belonging to it and about it, an extraordinary degree of care, an anxiety for its preservation, due, if we may so speak, to its value and its tenderness. It is lodged in a strong, deep, bony socket, composed by the junction of seven different bones,* hollowed out at their edges. In some few species, as that of the coatimondi,† the orbit is not bony throughout; but whenever this is the case, the upper, which is the deficient part, is supplied by a cartilaginous ligament; a substitution which shows the same care. Within this socket it is embedded in fat, of all animal substances the best adapted both to its repose and motion. It is sheltered by the eyebrows—an arch of hair, which, like a thatched penthouse, prevents the sweat and moisture of the forehead from running down into it.

But it is still better protected by its *lid*. Of the superficial parts of the animal frame, I know none which, in its office and structure, is more deserving of attention than the eyelid. It defends the eye; it wipes it; it closes it in sleep. Are there, in any work of art whatever, purposes more evident than

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Heister, sect. 89. † Mem. R. Ac. Paris, p. 117.

those which this organ fulfils? or an apparatus for executing those purposes more intelligible, more appropriate, or more mechanical? If it be overlooked by the observer of nature, it can only be because it is obvious and familiar. This is a tendency to be guarded against. We pass by the plainest instances, whilst we are exploring those which are rare and curious; by which conduct of the understanding we sometimes neglect the strongest observations, being taken up with others which, though more recondite and scientific, are, as solid arguments, entitled to much less consideration.

In order to keep the eye moist and clean (which qualities are necessary to its brightness and its use,) a wash is constantly supplied by a secretion for the purpose; and the superfluous brine is conveyed to the nose through a perforation in the bone as large as a goose-quill. When once the fluid has entered the nose, it spreads itself upon the inside of the nostril, and is evaporated by the current of warm air which, in the course of respiration, is continually passing over it. Can any pipe or outlet, for carrying off the waste liquor from a dye-house or a distillery, be more mechanical than this is? It is easily perceived that the eye must want moisture: but could the want of the eye generate the gland which produces the tear, or bore the hole by which it is discharged—a hole through a bone?

It is observable that this provision is not found in fish—the element in which they live supplying a constant lotion to the eye.

It were, however, injustice to dismiss the eye as a piece of mechanism, without noticing that most exquisite of all contrivances, the *nictitating membrane*, which is found in the eyes of birds and of many quadrupeds. Its use is to sweep the eye, which it does in an instant; to spread over it the lacrymal humor; to defend it also from sudden injuries; yet not totally, when drawn upon the pupil, to shut out the light. The commodiousness with which it lies folded up in the upper corner of the eye, ready for use and action, and the quickness with which it executes its purpose, are properties known and obvious to every observer; but what is equally admirable, though not quite so obvious, is the combination of two kinds of substance, muscular and elastic, and of two different kinds of action, by which the motion of this membrane is performed. It is not, as in ordinary cases, by the action of two antagonist muscles, the one pulling forward and the other backward, that a reciprocal change is effected; but it is thus: the membrane itself is an elastic substance, capable of being drawn out by force like a piece of elastic gum, and by its own elasticity returning, when the force is removed, to its former position. Such being its nature, in order to fit it up for its office, it is connected, by a tendon or thread, with a muscle in the back part of the ye: this tendon or thread, though strong, is so ne as not to obstruct the sight, even when it passes cross it; and the muscle itself, being placed in ie *back* part of the eye, derives from its situation ie advantage, not only of being secure, but of eing out of the way; which it would hardly have een in any position that could be assigned to it in ie anterior part of the orb, where its function lies. Vhen the muscle behind the eye contracts, the iembrane, by means of the communicating thread, s instantly drawn over the fore-part of it. When ie muscular contraction (which is a positive and iost probably a voluntary effort) ceases to be exrted, the elasticity alone of the membrane brings back again to its position.* Does not this, if any iing can do it, bespeak an artist, master of his ork, acquainted with his materials? "Of a thouand other things," say the French academicians, we perceive not the contrivance, because we unerstand them only by their effects, of which we now not the causes: but we here treat of a mahine, all the parts whereof are visible, and which eed only be looked upon to discover the reasons f its motion and action."†

In the configuration of the muscle which, though

* Phil. Trans. 1796.

† Memoirs for a Natural History of Animals, by the Royal cademy of Sciences at Paris, done into English by order of the oyal Society, 1701, p. 249.

placed behind the eye, draws the nictitating membrane over the eye, there is, what the authors just now quoted deservedly call a marvellous mechanism. I suppose this structure to be found in other animals; but, in the memoirs from which this account is taken, it is anatomically demonstrated only in the cassowary. The muscle is *passed through a loop formed by another muscle;* and is there inflected as if it were round a pully. This is a peculiarity, and observe the advantage of it. A single muscle with a straight tendon, which is the common muscular form, would have been sufficient, if it had had power to draw far enough. But the contraction necessary to draw the membrane over the whole eye required a longer muscle than could lie straight at the bottom of the eye. Therefore, in order to have a greater length in a less compass, the chord of the main muscle makes an angle. This so far answers the end; but still further, it makes an angle, not round a fixed pivot, but round a loop formed by another muscle, which second muscle, whenever it contracts, of course twitches the first muscle at the point of inflection, and thereby assists the action designed by both.

One question may possibly have dwelt in the reader's mind during the perusal of these observations, namely, why should not the Deity have given to the animal the faculty of vision *at once?* Why this circuitous perception; the ministry of so many neans; an element provided for the purpose; re-ected from opaque substances, refracted through ransparent ones; and both according to precise aws; then, a complex organ, an intricate and ar-ficial apparatus, in order, by the operation of this lement, and in conformity with the restrictions of nese laws, to produce an image upon a membrane ommunicating with the brain? Wherefore all nis? Why make the difficulty in order to sur-nount it? If to perceive objects by some other node than that of touch, or objects which lay out f the reach of that sense, were the thing propos-d, could not a simple volition of the Creator have ommunicated the capacity? Why resort to con-rivance where power is omnipotent? Contriv-nce, by its very definition and nature, is the re-uge of imperfection. To have recourse to expe-ients implies difficulty, impediment, restraint, de-ect of power. This question belongs to the other enses as well as to sight; to the general functions f animal life, as nutrition, secretion, respiration; o the economy of vegetables; and indeed to al-nost all the operations of nature. The question, nerefore, is of very wide extent; and amongst ther answers which may be given to it, besides easons of which probably we are ignorant, one nswer is this: It is only by the display of con-rivance that the existence, the agency, the wisdom f the Deity, *could* be testified to his rational creatures. This is the scale by which we ascend t all the knowledge of our Creator which we po sess, so far as it depends upon the phenomena c the works of nature. Take away this, and yo take away from us every subject of observatio and ground of reasoning; I mean, as our ration faculties are formed at present. Whatever is don God could have done without the intervention instruments or means; but it is in the constructio of instruments, in the choice and adaptation means, that a creative intelligence is seen. It this which constitutes the order and beauty of th universe. God, therefore, has been pleased to pr scribe limits to his own power, and to work h ends within those limits. The general laws of ma ter have perhaps prescribed the nature of these l mits; its inertia; its reaction; the laws whic govern the communication of motion, the refra tion and reflection of light, and the constitution fluids non-elastic and elastic, the transmission sound through the latter; the laws of magnetism of electricity; and probably others yet undisco ered. These are general laws; and when a pa ticular purpose is to be effected, it is not by ma ing a new law, nor by the suspension of the o ones, nor by making them wind, and bend, an yield to the occasion, (for nature with great stead ness adheres to and supports them,) but it is, a we have seen in the eye, by the interposition of a apparatus, corresponding with these laws, and suited to the exigency which results from them, that the purpose is at length attained. As we have said, therefore, God prescribes limits to his power, that he may let in the exercise and thereby exhibit demonstrations of his wisdom. For then, *i. e.* such laws and limitations being laid down, it is as though one Being should have fixed certain rules, and, if we may so speak, provided certain materials, and afterwards have committed to another Being, out of these materials, and in subordination to these rules, the task of drawing forth a creation: a supposition which evidently leaves room and induces indeed a necessity for contrivance. Nay, there may be many such agents, and many ranks of these. We do not advance this as a doctrine either of philosophy or of religion; but we say that the subject may safely be represented under this view; because the Deity, acting himself by general laws, will have the same consequences upon our reasoning as if he had prescribed these laws to another. It has been said, that the problem of creation was, "attraction and matter being given, to make a world out of them;" and, as above explained, this statement perhaps does not convey a false idea.

We have made choice of the eye as an instance upon which to rest the argument of this chapter. Some single example was to be proposed; and the eye offered itself under the advantage of admittin of a strict comparison with optical instruments The ear, it is probable, is no less artificially an mechanically adapted to its office than the eye But we know less about it: we do not so well un derstand the action, the use, or the mutual depend ency of its internal parts. Its general form, how ever, both external and internal, is sufficient t show that it is an instrument adapted to the recep tion of *sound;* that is to say, already knowing tha sound consists in pulses of the air, we perceive, i the structure of the ear, a suitableness to receiv impressions from this species of action, and to pro pagate these impressions to the brain. For of wha does this structure consist? An external ear (th concha) calculated, like an ear trumpet, to catc and collect the pulses of which we have spoken in large quadrupeds, turning to the sound, and pos sessing a configuration as well as motion evidentl fitted for the office: of a tube which leads into th head, lying at the root of this outward ear, th folds and sinuses thereof tending and conductin the air towards it: of a thin membrane, like th pelt of a drum, stretched across this passage upo a bony rim: of a chain of moveable and infinitel curious bones, forming a communication, and th only communication that can be observed, betwee the membrane last mentioned and the interio channels and recesses of the skull: of cavities imilar in shape and form to wind instruments of ausic, being spiral or portions of circles; of the ustachian tube, like the hole in a drum, to let the ir pass freely into and out of the barrel of the ear, s the covering membrane vibrates, or as the tem-erature may be altered: the whole labyrinth hewn ut of a rock; that is, wrought into the substance f the hardest bone of the body. This assemblage f connected parts constitutes together an appara-us plainly enough relative to the transmission of ound, or of the impulses received from sound, nd only to be lamented in not being better un-erstood.

The communication within, formed by the small ones of the ear, is, to look upon, more like what e are accustomed to call machinery, than any ing I am acquainted with in animal bodies. It eems evidently designed to continue towards the ensorium the tremulous motions which are excited the membrane of the tympanum, or what is bet-r known by the name of the "drum of the ear." he compages of bones consists of four, which are disposed, and so hinge upon one another, as that the membrane, the drum of the ear, vibrate, all e four are put in motion together; and, by the sult of their action, work the base of that which the last in the series, upon an aperture which it oses, and upon which it plays, and which aper-re opens into the tortuous canals that lead to the brain. This last bone of the four is called tl *stapes.* The office of the drum of the ear is to sprea out an extended surface, capable of receiving tl impressions of sound, and of being put by the into a state of vibration. The office of the stapes to repeat these vibrations. It is a repeating frigat stationed more within the line. From which a count of its action may be understood how tl sensation of sound will be excited by any thin which communicates a vibratory motion to tl stapes, though not, as in all ordinary cases, throug the intervention of the membrana tympani. Th is done by solid bodies applied to the bones of tl skull, as by a metal bar holden at one end b tween the teeth, and touching at the other end tremulous body. It likewise appears to be done, a considerable degree, by the air itself, even whe this membrane, the drum of the ear, is greatly da maged. Either in the natural or preternatural sta of the organ, the use of the chain of bones is propagate the impulse in a direction towards th brain, and to propagate it with the advantage of lever; which advantage consists in increasing th force and strength of the vibration, and at th same time diminishing the space through which oscillates; both of which changes may augment facilitate the still deeper action of the audito nerves.

The benefit of the eustachian tube to the orga may be made out upon pneumatic principles. Behind the drum of the ear is a second cavity, or barrel, called the tympanum. The eustachian tube is a slender pipe, but sufficient for the passage of air, leading from this cavity into the back part of the mouth. Now, it would not have done to have had a vacuum in this cavity; for, in that case, the pressure of the atmosphere from without would have burst the membrane which covered it. Nor would it have done to have filled the cavity with lymph, or any other secretion; which would necessarily have obstructed both the vibration of the membrane and the play of the small bones. Nor, lastly, would it have done to have occupied the space with confined air, because the expansion of that air by heat, or its contraction by cold, would have distended or relaxed the covering membrane in a degree inconsistent with the purpose which it was designed to execute. The only remaining expedient, and that for which the eustachian tube serves, is to open to this cavity a communication with the external air. In one word, it exactly answers the purpose of the hole in a drum.

The membrana tympani itself, likewise, deserves all the examination which can be made of it. It is not found in the ears of fish; which furnishes an additional proof of what indeed is indicated by every thing about it, that it is appropriated to the action of air, or of an elastic medium. It bears an obvious resemblance to the pelt or head of a drum from which it takes its name. It resembles also a drum-head in this principal property, that its use depends upon its tension. *Tension* is the state essential to it. Now we know that, in a drum, the pelt is carried over a hoop, and braced as occasion requires, by the means of strings attached to its circumference. In the membrane of the ear the same purpose is provided for more simply, but no less mechanically nor less successfully, by a different expedient, viz. by the end of a bone (the handle of the malleus) pressing upon its centre. It is only in very large animals that the texture of this membrane can be discerned. In the Philosophica Transactions for the year 1800 (vol. 1) Mr. Everard Home has given some curious observations upon the ear, and the drum of the ear of an *elephant*. He discovered in it what he calls a radiatec muscle—that is, straight muscular fibres passing along the membrane from the circumference to the centre—from the bony rim which surrounds it towards the handle of the malleus, to which the central part is attached. This muscle he suppose to be designed to bring the membrane into unison with different sounds; but then he also discovere that this muscle itself cannot act, unless the membrane be drawn to a stretch, and kept in a due stat of tightness by what may be called a foreign forc —viz. the action of the muscles of the malleus

Supposing his explanation of the use of the parts to be just, our author is well founded in the reflection which he makes upon it—"that this mode of adapting the ear to different sounds, is one of the most beautiful applications of muscles in the body; *the mechanism is so simple, and the variety of effects so great.*"

In another volume of the Transactions above referred to, and of the same year, two most curious cases are related of persons who retained the sense of hearing, not in a perfect but in a very considerable degree, notwithstanding the almost total loss of the membrane we have been describing. In one of these cases, the use here assigned to that membrane, of modifying the impressions of sound by change of tension, was attempted to be supplied by straining the muscles of the outward ear. "The external ear," we are told, "had acquired a distinct motion upward and backward, which was observable whenever the patient listened to any thing which he did not distinctly hear; when he was addressed in a whisper, the ear was seen immediately to move; when the tone of voice was louder, it then remained altogether motionless."

It appears probable, from both these cases, that a collateral if not principal use of the membrane is to cover and protect the barrel of the ear which lies behind it. Both the patients suffered from cold: one, "a great increase of deafness from catching cold;" the other, "very considerable pain from exposure to a stream of cold air." Bad effects therefore followed from this cavity being left open to the external air; yet, had the Author of Nature shut it up by any other cover than what was capable, by its texture, of receiving vibrations from sound, and, by its connection with the interior parts, of transmitting those vibrations to the brain, the use of the organ, so far as we can judge, must have been entirely obstructed.

CHAPTER IV.

ON THE SUCCESSION OF PLANTS AND ANIMALS.

The *generation* of the animal no more accounts for the contrivance of the eye or ear, than, upon the supposition stated in the preceding chapter, the production of a watch by the motion and mechanism of a former watch, would account for the skill and attention evidenced in the watch so produced—than it would account for the disposition of the wheels, the catching of their teeth, the relation of the several parts of the works to one another, and to their common end; for the suitableness of their forms and places to their offices, for their connection, their operation, and the useful result of that operation. I do insist most strenuously upon the correctness of this comparison; that it holds as to every mode of specific propagation; and that whatever was true of the watch, under the hypothesis above mentioned, is true of plants and animals.

I. To begin with the fructification of plants. Can it be doubted but that the seed contains a particular organization? Whether a latent plantule with the means of temporary nutrition, or whatever else it be, it encloses an organization suited to the germination of a new plant. Has the plant which produced the seed any thing more to do with that organization, than the watch would have had to do with the structure of the watch which was produced in the course of its mechanical movement? I mean—Has it any thing at all to do with the *contrivance*? The maker and contriver of one watch, when he inserted within it a mechanism suited to the production of another watch, was, in truth, the maker and contriver of that other watch. All the properties of the new watch were to be referred to his agency: the design manifested in it, to his intention: the art, to him as the artist; the collocation of each part, to his placing: the action, effect, and use, to his counsel, intelligence and workmanship. In producing it by the intervention of a former watch, he was only working by one set of tools instead of another. So it is with the plant, and the seed produced by it. Can any distinction be assigned between the two cases; between the producing watch and the producing plant; both passive unconscious substances; both, by the organization which was given to them, producing their like, without understanding or design; both, that is, instruments?

II. From plants we may proceed to oviparous ani mals: from seeds to eggs. Now I say, tnat the bird has the same concern in the formation of the egg which she lays, as the plant has in that of the seed which it drops; and no other nor greater. The internal constitution of the egg is as much a secret to the hen as if the hen were inanimate. Her will cannot alter it, or change a single feather of the chick. She can neither foresee nor determine of which sex her brood shall be, or how many of either; yet the thing produced shall be, from the first, very different in its make according to the sex which it bears. So far, therefore, from adapting the means, she is not beforehand apprized of the effect. If there be concealed within that smooth shell a provision and a preparation for the production and nourishment of a new animal, they are not of her providing or preparing; if there be contrivance, it is none of hers. Although, therefore, there be the difference of life and perceptivity between the animal and the plant, it is a difference which enters not into the account;—it is a foreign circumstance; it is a difference of properties not employed. The animal function and the vegetable function are alike destitute of any design which can operate upon the form of the thing produced. The plant has no design in producing the seed—no comprehension of the nature or use of what it produces: the bird, with respect to its egg, is not above the plant with respect to its seed. Neither the one nor the other bears that sort of relation to what proceeds from them which a joiner does to the chair which he makes. Now a cause which bears *this* relation to the effect, is what we want, in order to account for the suitableness of means to an end—the fitness and fitting of one thing to another; and this cause the parent plant or animal does not supply.

It is further observable concerning the propagation of plants and animals, that the apparatus employed exhibits no resemblance to the thing produced; in this respect, holding an analogy with instruments and tools of art. The filaments, antheræ, and stigmata of flowers, bear no more resemblance to the young plant, or even to the seed which is formed by their intervention, than a chisel or a plain does to a table or a chair. What then are the filaments, antheræ, and stigmata of plants but instruments, strictly so called?

III. We may advance from animals which bring forth eggs, to animals which bring forth their young alive; and of this latter class, from the lowest to the highest; from irrational to rational life, from brutes to the human species; without perceiving, as we proceed, any alteration whatever in the terms of the comparison. The rational animal does not produce its offspring with more certainty or success than the irrational animal: a man than a quadruped, a quadruped than a bird; nor (for we may follow the gradation through its whole scale) a bird than a plant; nor a plant than a watch, a piece of dead mechanism, would do, upon the supposition which has already so often been repeated. Rationality, therefore, has nothing to do in the business. If an account must be given of the contrivance which we observe; if it be demanded, whence arose either the contrivance by which the young animal is produced, or the contrivance manifested in the young animal itself, it is not from the reason of the paren that any such account can be drawn. He is the caus of his offspring, in the same sense as that in which gardener is the cause of the tulip which grows upo his parterre, and in no other. We admire the flower we examine the plant; we perceive the conduciveness of many of its parts to their end and office: we observ a provision for its nourishment, growth, protection, an fecundity; but we never think of the gardener in al this. We attribute nothing of this to his agency: ye it may still be true, that without the gardener w should not have had the tulip. Just so it is with th succession of animals, even of the highest order. Fo the contrivance discovered in the structure of the thin produced, we want a contriver. The parent is not tha contriver: his consciousness decides that questio He is in total ignorance why that which is produce took its present form rather than any other. It is fo him only to be astonished by the effect. We can n more look therefore to the intelligence of the paren animal for what we are in search of—a cause of rela tion, and of subserviency of parts to their use, whic relation and subserviency we see in the procreate body—than we can refer the internal conformation o an acorn to the intelligence of the oak from which i dropped, or the structure of the watch to the intelligenc of the watch which produced it: there being no differ ence, as far as argument is concerned, between an in telligence which is not exerted, and an intelligenc which does not exist.

CHAPTER V.

APPLICATION OF THE ARGUMENT CONTINUED.

Every observation which was made in our first chapter concerning the watch, may be repeated with strict propriety concerning the eye; concerning animals; concerning plants; concerning, indeed, all the organized parts of the works of nature. As,

I. When we are inquiring simply after the *existence* of an intelligent Creator, imperfection, inaccuracy, liability to disorder, occasional irregularities, may subsist in a considerable degree, without inducing any doubt into the question: just as a watch may frequently go wrong, seldom perhaps exactly right, may be faulty in some parts, defective in some, without the smallest ground of suspicion from thence arising that it was not a watch, not made, or not made for the purpose ascribed to it. When faults are pointed out, and when a question is started concerning the skill of the artist, or dexterity with which the work is executed, then, indeed, in order to defend these qualities from accusation, we must be able, either to expose some intractableness and imperfection in the materials, or point out some invincible difficulty in the execution, into which imperfection and difficulty the matter of complaint may be resolved; or, if we cannot do this, we must adduce such specimens of consummate art and contrivance proceeding from the same hand as may convince the inquirer of the existence, in the case before him, of impediments like those which we have mentioned, although, what from the nature of the case is very likel to happen, they be unknown and unperceived b him. This we must do in order to vindicate the ar tist's skill, or at least the perfection of it; as we mus also judge of his intention, and of the provisions em ployed in fulfilling that intention, not from an instanc in which they fail, but from the great plurality of in stances in which they succeed. But, after all, thes are different questions from the question of the artist' existence; or, which is the same, whether the thin before us be a work of art or not; and the question ought always to be kept separate in the mind. S likewise it is in the works of nature. Irregularitie and imperfections are of little or no weight in the con sideration, when that consideration relates simply to th existence of a Creator. When the argument respect his attributes, they are of weight; but are then to b taken in conjunction (the attention is not to rest upo them, but they are to be taken in conjunction) with th unexceptionable evidences which we possess of skill power and benevolence, displayed in other instances which evidences may, in strength, number, and variety be such, and may so overpower apparent blemishes, a to induce us, upon the most reasonable ground, to be lieve that these last ought to be referred to some cause though we be ignorant of it, other than defect o knowledge or of benevolence in the author.

II. There may be also parts of plants and animals as there were supposed to be of the watch, of which in some instances the operation, in others the use, i unknown. These form different cases; for the operation may be unknown, yet the use be certain. Thus it is with the lungs of animals. It does not, I think, appear, that we are acquainted with the action of the air upon the blood, or in what manner that action is communicated by the lungs; yet we find that a very short suspension of their office destroys the life of the animal. In this case, therefore, we may be said to know the use, nay, we experience the necessity, of the organ, though we be ignorant of its operation. Nearly the same thing may be observed of what is called the lymphatic system. We suffer grievous inconveniences from its disorder, without being informed of the office which it sustains in the economy of our bodies. There may possibly also be some few examples of the second class, in which not only the operation is unknown, but in which experiments may seem to prove that the part is not necessary; or may leave a doubt how far it is even useful to the plant or animal in which it is found. This is said to be the case with the spleen, which has been extracted from dogs without any sensible injury to their vital function. Instances of the former kind, namely, in which we cannot explain the operation, may be numerous; for they will be so in proportion to our ignorance. They will be more or fewer to different persons, and in different stages of science. Every improvement of knowledge diminishes their number. There is hardly, perhaps, a year passes that does not, in the works of nature, bring some operation, or some mode of operation, to light, which was before undiscovered,—probably unsuspected. Instances of the second kind, namely, where the part appears to be totally useless, I believe to be extremely rare; compared wit the number of those of which the use is evident, they ar beneath any assignable proportion, and perhaps hav been never submitted to a trial and examination suffi ciently accurate, long enough continued, or often enoug repeated. No accounts which I have seen are satis factory. The mutilated animal may live and grov fat, (as was the case of the dog deprived of its spleen, yet may be defective in some other of its functions which whether they can all, or in what degree of vigo and perfection, be performed, or how long preserve without the extirpated organ, does not seem to be as certained by experiment. But to this case, even wer it fully made out, may be applied the consideratio which we suggested concerning the watch, viz. tha these superfluous parts do not negative the reasonin which we instituted concerning those parts which ar useful, and of which we know the use; the indicatio of contrivance, with respect to them, remains as i was before.

III. One atheistic way of replying to our observa tions upon the works of nature, and to the proofs of a Deity which we think that we perceive in them, is t tell us, that all which we see must necessarily hav had some form, and that it might as well be its presen as any other. Let us now apply this answer to th eye, as we did before to the watch. Something o other must have occupied that place in the animal' head; must have filled up, as we say, that socket we will say, also, that it must have been of that sor of substance which we call animal substance, as flesh, bone, membrane, or cartilage, &c. But that it should have been an *eye*, knowing as we do what an eye comprehends,—viz. that it should have consisted, first, of a series of transparent lenses, (very different, by-the-by, even in their substance, from the opaque materials of which the rest of the body is, in general at least, composed; and with which the whole of its surface, this single portion of it excepted, is covered,) secondly, of a black cloth or canvass (the only membrane in the body which is black) spread out behind these lenses, so as to receive the image formed by pencils of light transmitted through them; and placed at the precise geometrical distance, at which, and at which alone, a distinct image could be formed, namely, at the concourse of the refracted rays: thirdly, of a large nerve communicating between this membrane and the brain; without which, the action of light upon the membrane, however modified by the organ, will be lost to the purposes of sensation:—that this fortunate conformation of parts should have been the lot, not of one individual out of many thousand individuals, like the great prize in a lottery, or like some singularity in nature, but the happy chance of a whole species: nor of one species out of many thousand species, with which we are acquainted, but of by far the greatest number of all that exist; and that under varieties, not casual or capricious, but bearing marks of being suited to their respective exigencies:—that all this should have taken place, merely because something must have occupied these points on every animal's forehead;—or, that all this should be thought to be accounted for by the short answer, "that whatever was there must have had som form or other," is too absurd to be made more so by an augmentation. We are not contented with this answer we find no satisfaction in it, by way of accounting fo appearances of organization far short of those of th eye, such as we observe in fossil shells, petrified bones or other substances which bear the vestiges of anima or vegetable recrements, but which, either in respec to utility, or of the situation in which they are dis covered, may seem accidental enough. It is no way of accounting even for these things, to say, that th stone, for instance, which is shown to us (supposin the question to be concerning a petrification) mus have contained some internal conformation or other Nor does it mend the answer to add, with respect t the singularity of the conformation, that after the event it is no longer to be computed what the chances wer against it. This is always to be computed when th question is, whether a useful or imitative comformatio be the produce of chance or not: I desire no greate certainty in reasoning than that by which chance i excluded from the present disposition of the natura world. Universal experience is against it. What doe chance ever do for us? In the human body, for in stance, chance, *i. e.* the operation of causes withou design, may produce a wen, a wart, a mole, a pimple but never an eye. Amongst inanimate substances, a clod, a pebble, a liquid drop might be; but never was a watch, a telescope, an organized body of any kind, an swering a valuable purpose by a complicated mechan ism, the effect of chance. In no assignable instance hath such a thing existed without intention somewhere.

IV. There is another answer which has the same effect as the resolving of things into chance; which answer would persuade us to believe, that the eye, the animal to which it belongs, every other animal, every plant, indeed every organized body which we see, are only so many out of the possible varieties and combinations of being which the lapse of infinite ages has brought into existence; that the present world is the relic of that variety; millions of other bodily forms, and other species having perished, being, by the defect of their constitution, incapable of preservation, or of continuance by generation. Now there is no foundation whatever for this conjecture in any thing which we observe in the works of nature; no such experiments are going on at present; no such energy operates as that which is here supposed, and which should be constantly pushing into existence new varieties of beings. Nor are there any appearances to support an opinion, that every possible combination of vegetable or animal structure has formerly been tried. Multitudes of conformations, both of vegetables and animals, may be conceived capable of existence and succession, which yet do not exist. Perhaps almost as many forms of plants might have been found in the fields as figures of plants can be delineated upon paper. A countless variety of animals might have existed which do not exist. Upon the supposition here stated, we should see unicorns and mermaids, sylphs and centaurs, the fancies of painters, and the fables of poets, realized by examples. Or, if it be alleged that these may transgress the bounds of possible life and propagation, we might at least have nations of human beings without nails upon their fingers, with more or fewer fingers and toes than ten, some with one eye, others with one ear, with one nostril, or without the sense of smelling at all. All these, and a thousand other imaginable varieties, might live and propagate. We may modify any one species many different ways, all consistent with life, and with the actions necessary to preservation, although affording different degrees of conveniency and enjoyment to the animal. And if we carry these modifications through the different species which are known to subsist, their number would be incalculable. No reason can be given why, if these deperdits ever existed, they have now disappeared. Yet, if all possible existences have been tried, they must have formed part of the catalogue.

But moreover, the division of organized substances into animals and vegetables, and the distribution and sub-distribution of each into genera and species, which distribution is not an arbitrary act of the mind, but founded in the order which prevails in external nature, appear to me to contradict the supposition of the present world being the remains of an indefinite variety of existences; of a variety which rejects all plan. The hypothesis teaches, that every possible variety of being hath, at one time or other, found its way into existence, (by what cause or in what manner is not said,) and that those which are badly formed perished; but how or why those which survived should be cast, as we see that plants and animals are cast, into regu-

ar classes, the hypothesis does not explain; or rather
he hypothesis is inconsistent with this phenomenon.

The hypothesis, indeed, is hardly deserving of the onsideration which we have given to it. What should re think of a man who, because we had never ourelves seen watches, telescopes, stocking-mills, steamngines, &c. made, knew not how they were made, or could prove by testimony when they were made, r by whom, would have us believe that these mahines, instead of deriving their curious structures from he thought and design of their inventors and contriers, in truth derive them from no other origin than his: viz. that a mass of metals and other materials aving run, when melted, into all possible figures, and ombined themselves in all possible forms, and shapes, nd proportions, these things which we see are what rere left from the incident, as best worth preserving, nd, as such, are become the remaining stock of a maazine, which, at one time or other, has by this means ontained every mechanism, useful and useless, conenient and inconvenient, into which such like mateals could be thrown? I cannot distinguish the hyothesis, as applied to the works of nature, from this olution, which no one would accept as applied to a ollection of machines.

V. To the marks of contrivance discoverable in aniial bodies, and to the argument deduced from them ı proof of design and of a designing Creator, this turn s sometimes attempted to be given, namely, that the arts were not intended for the use, but that the use rose out of the parts. This distinction is intelligible.

A cabinet-maker rubs his mahogany with fish-skin yet it would be too much to assert that the skin of th dog-fish was made rough and granulated on purpos for the polishing of wood, and the use of cabinet-ma kers. Therefore the distinction is intelligible. But think that there is very little place for it in the work of nature. When roundly and generally affirmed o them, as it hath sometimes been, it amounts to suc another stretch of assertion as it would be to say, tha all the implements of the cabinet-maker's worksho as well as his fish-skin, were substances acciden tally configurated, which he had picked up and con verted to his use; that his adzes, saws, plains, an gimlets, were not made, as we suppose, to hew, cu smooth, shape out, or bore wood with; but that, thes things being made, no matter with what design, o whether with any, the cabinet-maker perceived tha they were applicable to his purpose, and turned then to account.

But, again. So far as this solution is attempted t be applied to those parts of animals the action of which does not depend upon the will of the animal, it is fraught with still more evident absurdity. Is it possi ble to believe that the eye was formed without any re gard to vision; that it was the animal itself which found out that, though formed with no such intention it would serve to see with; and that the use of the eye as an organ of sight resulted from this discovery and the animal's application of it? The same ques tion may be asked of the ear; the same of all the senses. None of the senses fundamentally depend upon e election of the animal; consequently neither upon s sagacity nor his experience. It is the impression hich objects make upon them that constitutes their e. Under that impression he is passive. He may ing objects to the sense, or within its reach; he may lect these objects; but over the impression itself he s no power, or very little; and that properly is the nse.

Secondly; there are many parts of animal bodies aich seem to depend upon the will of the animal in greater degree than the senses do, and yet with re- ect to which this solution is equally unsatisfactory. If apply the solution to the human body, for instance, forms itself into questions upon which no reasona- mind can doubt; such as, whether the teeth were ade expressly for the mastication of food, the feet for alking, the hands for holding? or whether, these ings as they are, being in fact in the amimal's pos- ssion, his own ingenuity taught him that they were nvertable to these purposes, though no such purposes ere contemplated in their formation?

All that there is of the appearance of reason in this ay of considering the subject is, that, in some cases, organization seems to determine the habits of the imal, and its choice to a particular mode of life; aich, in a certain sense, may be called "the use sing out of the part." Now, to all the instances in aich there is any place for this suggestion, it may be plied, that the organization determines the animal to bits beneficial and salutary to itself; and that this ect would not be seen so regularly to follow, if the

several organizations did not bear a concerted and c
trived relation to the substance by which the anin
was surrounded. They would, otherwise, be capa
ties without objects; powers without employme
The web-foot determines, you say, the duck to swi
but what would that avail if there were no water
swim in. The strong hooked bill and sharp talons
one species of bird determine it to prey upon anima
the soft straight bill and weak claws of another spec
determine it to pick up seeds: but neither determi
tion could take effect in providing for the sustenan
of the birds, if animal bodies and vegetable seeds d
not lie within their reach. The peculiar conformati
of the bill and tongue and claws of the woodpeck
determines that bird to search for his food amongst t
insects lodged behind the bark or in the wood of d
cayed trees; but what would this profit him if the
were no trees, no decayed trees, no insects lodged u
der their bark, or in their trunk? The proboscis wi
which the bee is furnished determines him to seek t
honey: but what would that signify if flowers su
plied none? Faculties thrown down upon animals
random, and without reference to the objects amid
which they are placed, would not produce to them t
services and benefits which we see; and if there
that reference, then there is intention.

Lastly; the solution fails entirely when applied
plants. The parts of plants answer their uses witho
any concurrence from the will or choice of the plan

VI. Others have chosen to refer everything to
principle of order in nature. A principle of order

e word: but what is meant by a principle of order different from an intelligent Creator, has not been plained either by definition or example; and, witht such explanation, it should seem to be a mere subtution of words for reasons, names for causes. Orr itself is only the adaptation of means to an end: a inciple of order, therefore, can only signify the mind d intention which so adapts them. Or, were it cable of being explained in any other sense, is there y experience, any analogy, to sustain it? Was a atch ever produced by a principle of order? and ay might not a watch be so produced as well as an e?

Furthermore, a principle of order, acting blindly and thout choice, is negatived by the observation that ler is not universal; which it would be if it issued m a constant and necessary principle: nor indiscrinate, which it would be if it issued from an uninligent principle. Where order is wanted, there we d it: where order is not wanted, *i. e.* where, if it vailed, it would be useless, there we do not find it. the structure of the eye, (for we adhere to our exple,) in the figure and position of its several parts, most exact order is maintained. In the forms of ks and mountains, in the lines which bound the asts of continents and islands, in the shape of bays d promontories, no order whatever is perceived, bease it would have been superfluous. No useful purse would have arisen from moulding rocks and untains into regular solids, bounding the channel the ocean by geometrical curves; or from the map of the world resembling a table of diagrams in Euclid Elements or Simpson's Conic Sections.

VII. Lastly; the confidence which we place in o observations upon the works of nature, in the mar which we discover of contrivance, choice, and desig and in our reasoning upon the proofs afforded u ought not to be shaken, as it is sometimes attempt to be done, by bringing forward to our view our ow ignorance, or rather the general imperfection of o knowledge of nature. Nor, in many cases, oug this consideration to affect us, even when it respec some parts of the subject immediately under our notic True fortitude of understanding consists in not suffe ing what we know to be disturbed by what we do n know. If we perceive a useful end, and means adapt to that end, we perceive enough for our conclusion. these things be clear, no matter what is obscure. Th argument is finished. For instance; if the utility vision to the animal which enjoys it, and the adapt tion of the *eye* to this office, be evident and certain, (a I can mention nothing which is more so,) ought it prejudice the inference which we draw from these pr mises, that we cannot explain the use of the spleen Nay, more: if there be parts of the eye, viz. the corne the crystalline, the retina, in their substance, figure a position, manifestly suited to the formation of an imag by the refraction of rays of light, at least as manifest as the glasses and tubes of a dioptric telescope a suited to that purpose, it concerns not the proof whic these afford of design, and of a designer, that there ma perhaps be other parts, certain muscles, for instanc r nerves in the same eye, of the agency or effect of which we can give no account, any more than we hould be inclined to doubt, or ought to doubt, about ie construction of a telescope, viz. for what purpose was constructed, or whether it was constructed at ll, because there belonged to it certain screws and ins, the use or action of which we did not compre-end. I take it to be a general way of infusing doubts nd scruples into the mind, to recur to its own igno-ınce, its own imbecility: to tell us that upon these ıbjects we know little; that little imperfectly; or ra-ıer, that we know nothing properly about the matter. 'hese suggestions so fall in with our consciousness as ›metimes to produce a general distrust of our faculties nd our conclusions. But this is an unfounded jealousy. 'he uncertainty of one thing does not necessarily af-ɛct the certainty of another thing. Our ignorance of ıany points need not suspend our assurance of a few. efore we yield, in any particular instance, to the cepticism which this sort of insinuation would induce, e ought accurately to ascertain whether our igno-ınce or doubt concern those precise points upon which ır conclusion rests. Other points are nothing. Our norance of other points may be of no consequence to ıese, though they be points, in various respects, of reat importance. A just reasoner removes from his onsideration, not only what he knows, but what he oes not know, touching matters not strictly connected ith his argument, *i. e.* not forming the very steps of is deduction: beyond these, his knowledge and his norance are alike relative.

CHAPTER VI.

THE ARGUMENT CUMULATIVE.

Were there no example in the world of contrivanc except that of the *eye*, it would be alone sufficient t support the conclusion which we draw from it, as t the necessity of an intelligent Creator. It could neve be got rid of; because it could not be accounted for b any other supposition which did not contradict all th principles we possess of knowledge; the principle according to which things do, as often as they can b brought to the test of experience, turn out to be true o false. Its coats and humors, constructed as the lense of a telescope are constructed, for the refraction of ray of light to a point, which forms the proper action o the organ; the provision in its muscular tendons fo turning its pupil to the object, similar to that which i given to the telescope by screws, and upon whicl power of direction in the eye the exercise of its offic as an optical instrument depends; the further provi sion for its defence, for its constant lubricity and mois ture, which we see in its socket and its lids, in it glands for the secretion of the matter of tears, its outle or communication with the nose for carrying off th liquid after the eye is washed with it; these provision compose altogether an apparatus, a system of parts, a preparation of means, so manifest in their design, s exquisite in their contrivance, so successful in their is sue, so precious, and so infinitely beneficial in thei use, as, in my opinion, to bear down all doubt that ca be raised upon the subject. And what I wish, under the title of the present chapter, to observe, is, that if other parts of nature were inaccessible to our inquiries, or even if other parts of nature presented nothing to our examination but disorder and confusion, the validity of this example would remain the same. If there were but one watch in the world, it would not be less certain that it had a maker. If we had never in our lives seen any but one single kind of hydraulic machine, yet, if of that one kind we understood the mechanism and use, we should be as perfectly assured that it proceeded from the hand and thought and skill of a workman, as if we visited a museum of the arts, and saw collected there twenty different kinds of machines for drawing water, or a thousand different kinds for other purposes. Of this point each machine is a proof independently of all the rest. So it is with the evidences of a divine agency. The proof is not a conclusion which lies at the end of a chain of reasoning, of which chain each instance of contrivance is only a link, and of which, if one link fail, the whole falls; but it is an argument separately supplied by every separate example. An error in stating an example effects only that example. The argument is cumulative, in the fullest sense of that term. The eye proves it without the ear; the ear without the eye. The proof in each example is complete; for when the design of the part, and the conduciveness of its structure to that design is shown, the mind may set itself at rest; no future consideration can detract any thing from the force of the example.

Paley.

CHAPTER VII.

OF THE MECHANICAL AND IMMECHANICAL PART AND FUNCTIONS OF ANIMALS AND VEGETABLES.

It is not that *every* part of an animal or vegetabl has not proceeded from a contriving mind; or tha every part is not constructed with a view to its prope end and purpose, according to the laws belonging t and governing the substance or the action made us of in that part; or that each part is not so constructe as to effectuate its purpose whilst it operates accordin to these laws; but it is because these laws themselve are not in all cases equally understood—or, wha amounts to nearly the same thing, are not equally ex emplified in more simple processes, and more simpl machines, that we lay down the distinction, here pro posed, between the mechanical parts of animals an vegetables.

For instance: the principle of muscular motion viz. upon what cause the swelling of the belly of th muscle, and consequent contraction of its tendons either by an act of the will, or by involuntary irrita tion, depends, is wholly unknown to us. The sub stance employed, whether it be fluid, gaseous, elastic electrical, or none of these, or nothing resemblin these, is also unknown to us: of course, the laws be longing to that substance, and which regulate its ac tion, are unknown to us. We see nothing similar t this contraction in any machine which we can mak or any process which we can execute. So far (it confessed) we are in ignorance, but no farther. This power and principle, from whatever cause it proceeds, being assumed, the collocation of the fibres to receive the principle, the disposition of the muscles for the use and application of the power, is mechanical; and is as intelligible as the adjustment of the wires and strings by which a puppet is moved. We see, therefore, as far as respects the subject before us, what is not mechanical in the animal frame, and what is. The nervous influence (for we are often obliged to give names to things which we know little about)—I say the nervous influence, by which the belly or middle of the muscle is swelled, is not mechanical. The utility of the effect we perceive—the means, or the preparation of means, by which it is produced, we do not. But obscurity as to the origin of muscular motion brings no doubtfulness into our observations, upon the sequel of the process: which observations relate—1st, to the constitution of the muscle, in consequence of which constitution, the swelling of the belly or middle part is necessarily and mechanically followed by a contraction of the tendons; 2dly, to the number and variety of the muscles, and the corresponding number and variety of useful powers which they supply to the animal, which is astonishingly great; 3dly, to the judicious, (if we may be permitted to use that term in speaking of the Author, or of the works of nature,) to the wise and well-contrived disposition of each muscle for its specific purpose; for moving the joint this way, and that way, and the other way; for pulling and drawing the part to which it is attached in a determinate and particular direction: which is a mechanical operation exemplified in a multitude of instances. To mention only one: The tendon of the trochlear muscle of the eye, to the end that it may draw in the line required, is passed through a cartilaginous ring, at which it is reverted, exactly in the same manner as a rope in a ship is carried over a block, or round a stay, in order to make it pull in the direction which is wanted. All this, as we have said, is mechanical, and is as accessible to inspection, as capable of being ascertained, as the mechanism of the automaton in the Strand. Supposing the automaton to be put in motion by a magnet, (which is probable,) it will supply us with a comparison very apt for our present purpose. Of the magnetic effluvium we know perhaps as little as we do of the nervous fluid. But, magnetic attraction being assumed, (it signifies nothing from what cause it proceeds,) we can trace, or there can be pointed out to us, with perfect clearness and certainty, the mechanism, viz. the steel bars, the wheels, the joints, the wires, by which the motion so much admired is communicated to the fingers of the image; and to make any obscurity, or difficulty, or controversy in the doctrine of magnetism, an objection to our knowledge or our certainty, concerning the contrivance, or the marks of contrivance, displayed in the automaton, would be exactly the same thing as it is to make our ignorance (which we acknowledge,) of the cause of nervous agency, or even of the substance and structure of the nerves themselves, a ground of question or suspicion as to the reasoning which we institute concerning the mechanical part of our frame. That an animal is a machine is a proposition neither correctly true nor wholly false. The distinction which we have been discussing will serve to show how far the comparison, which this expression implies, holds; and wherein it fails. And whether the distinction be thought of importance or not, it is certainly of importance to remember, that there is neither truth nor justice in endeavoring to bring a cloud over our understandings, or a distrust into our reasonings upon this subject, by suggesting that we know nothing of voluntary motion, of irritability, of the principle of life, of sensation, of animal heat, upon all which the animal functions depend; for, our ignorance of these parts of the animal frame concerns not at all our knowledge of the mechanical parts of the same frame. I contend, therefore, that there is mechanism in animals; that this mechanism is as properly such as it is in machines made by art; that this mechanism is intelligible and certain; that it is not the less so, because it often begins or terminates with something which is not mechanical; that whenever it is intelligible and certain, it demonstrates intention and contrivance, as well in the works of nature as in those of art; and that it is the best demonstration which either can afford.

But whilst I contend for these propositions, I do not exclude myself from asserting that there may be, and that there are, other cases in which, although we cannot exhibit mechanism, or prove indeed that mechanism is employed, we want not sufficient evidence to conduct us to the same conclusion.

There is what may be called the *chemical* part of our frame; of which, by reason of the imperfection of our chemistry, we can attain to no distinct knowledge; I mean, not to a knowledge, either in degree or kind, similar to that which we possess of the mechanical part of our frame. It does not, therefore, afford the same species of argument as that which mechanism affords; and yet it may afford an argument in a high degree satisfactory. The *gastric juice*, or the liquor which digests the food in the stomachs of animals, is of this class. Of all the menstrua it is the most active, the most universal. In the human stomach, for instance, consider what a variety of strange substances, and how widely different from one another, it in a few hours reduces to a uniform pulp, milk, or mucilage. It seizes upon every thing; it dissolves the texture of almost every thing that comes in its way. The flesh of perhaps all animals; the seeds and fruits of the greatest number of plants; the roots and stalks, and leaves of many, hard and tough as they are, yield to its powerful pervasion. The change wrought by it is different from any chemical solution which we can produce, or with which we are acquainted, in this respect as well as many others, that, in our chemistry, particular menstrua act only upon particular substances. Consider, moreover, that this fluid, stronger in its operation than a caustic alkali, or mineral acid, than red precipitate or aqua-fortis itself, is nevertheless as mild, and bland, and inoffensive to the touch or taste as saliva or gum-water, which it much resembles. Consider, I say, these several properties of the digestive organ, and of the juice with which it is supplied, or rather with which it is made to supply itself, and you will confess it to be entitled to a name which it has sometimes received, that of "the chemical wonder of animal nature."

Still we are ignorant of the composition of this fluid, and of the mode of its action; by which is meant, that we are not capable, as we are in the mechanical part of our frame, of collating it with the operations of art. And this I call the imperfection of our chemistry; for, should the time ever arrive, which is not, perhaps, to be despaired of, when we can compound ingredients so as to form a solvent which will act in the manner in which the gastric juice acts, we may be able to ascertain the chemical principles upon which its efficacy depends, as well as from what part, and by what concoction, in the human body these principles are generated and derived.

In the mean time ought that, which is in truth the defect of our chemistry, to hinder us from acquiescing in the inference which a production of nature, by its place, its properties, its action, its surprising efficacy, its invaluable use, authorises us to draw in respect of a creative design?

Another most subtle and curious function of animal bodies is *secretion*. This function is semi-chemical and semi-mechanical; exceedingly important and diversified in its effects, but obscure in its process and in its apparatus. The importance of the secretory organs is but too well attested by the diseases which an excessive, a deficient, or a vitiated secretion is almost sure of producing. A single secretion being wrong is enough to make life miserable, or sometimes to destroy it. Nor is the variety less than the importance. From one and the same blood, (I speak of the human body,) about twenty different fluids are separated; in their sensible properties, in taste, smell, color, and consistency the most unlike one another that is possible; thick, thin, salt, bitter, sweet: and if from our own we pass to other species of animals, we find amongst their secretions not only the most various but the most opposite properties; the most nutritious aliment, the deadliest poison; the sweetest perfumes, the most fœtid odors. Of these the greater part, as the gastric juice, the saliva, the bile, the slippery mucilage which lubricates the joints, the tears which moisten the eye, the wax which defends the ear, are, after they are secreted, made use of in the animal economy, are evidently subservient, and are actually contributing to the utilities of the animal itself. Other fluids seem to be separated only to be rejected. That this also is necessary, (though why it was originally necessary we cannot tell,) is shown by the consequence of the separation being long suspended, which consequence is disease and death. Akin to secretion, if not the same thing, is assimilation by which one and the same blood is converted into bone, muscular flesh, nerves, membranes, tendons; things as different as the wood and iron, canvass and cordage, of which a ship with its furniture is composed. We have no operation of art wherewith exactly to compare all this, for no other reason, perhaps, than that all operations of art are exceeded by it. No chemical election, no chemical analysis or resolution of a substance into its constituent parts, no mechanical sifting or division that we are acquainted with, in perfection or variety come up to animal secretion. Nevertheless, the apparatus and process are obscure, not to say absolutely concealed from our inquiries. In a few, and only a few instances, we can discern a little of the constitution of a gland. In the kidneys of large animals, we can trace the emulgent artery dividing itself into an infinite number of branches; their extremities every where communicating with little round bodies, in the substance of which bodies the secret of the machinery seems to reside, for there the change is made. We can discern pipes laid from these round bodies towards the pelvis, which is a basin within the solid of the kidney. We can discern these pipes joining and collecting together into larger pipes; and, when so collected, ending in innumerable papillæ, through which the secreted fluid is continually oozing into its receptacle. This is all we know of the mechanism of a gland, even in the case in which it seems most capable of being investigated. Yet to pronounce that we know nothing of animal secretion, or nothing satisfactorily, and with that concise remark to dismiss the article from our argument, would be to dispose of the subject very hastily and very irrationally. For the purpose which we want, that of evincing intention, we know a great deal. And what we know is this. We see the blood carried by a pipe, conduit, or duct, *to* the gland. We see an organized apparatus, be its construction or action what it will, which we call that gland. W see the blood, or part of the blood, after it has passe through and undergone the action of the gland, com ing *from* it by an emulgent vein or artery, *i. e.* b another pipe or conduit. And we see also at the sam time a new and specific fluid issuing from the sam gland by its excretory duct, *i. e.* by a third pipe o conduit; which new fluid is in some cases discharge out of the body, in more cases retained within it, an there executing some important and intelligent office Now supposing, or admitting, that we know nothin of the proper internal constitution of a gland, or of th mode of its acting upon the blood, then our situation i precisely like that of an unmechanical looker on, wh stands by a stocking-loom, a corn-mill, a carding-ma chine, or a thrashing-machine, at work, the fabric an mechanism of which, as well as all that passes withi is hidden from his sight by the outside case; or, i seen, would be too complicated for his uninformed, u instructed understanding to comprehend. And wha is that situation? This spectator, ignorant as he i sees at one end a material enter the machine, as u ground grain the mill, raw cotton the carding-machin sheaves of unthrashed corn the thrashing-machine and, when he casts his eye to the other end of th apparatus, he sees the material issuing from it in new state; and, what is more, in a state manifestl adapted to future uses; the grain in meal fit for th making of bread, the wool in rovings ready for spin ning into threads, the sheaf in corn dressed for th mill. Is it necessary that this man, in order to be co vinced that design, that intention, that contrivance has been employed about the machine, should be allowed to pull it to pieces; should be enabled to examine the parts separately; explore their action upon one another, or their operation, whether simultaneous or successive, upon the material which is presented to them? He may long to do this to gratify his curiosity; he may desire to do it to improve his theoretic knowledge; or he may have a more substantial reason for requesting it, if he happen, instead of a common visiter, to be a millwright by profession, or a person sometimes called in to repair such-like machines when out of order; but for the purpose of ascertaining the existence of counsel and design in the formation of the machine, he wants no such intromission or privity. What he sees is sufficient. The effect upon the material, the change produced in it, the utility of that change for future applications, abundantly testify, be the concealed part of the machine or of its construction what it will, the hand and agency of a contriver.

If any conformation were wanting to the evidence which the animal secretions afford of design, it may be derived, as has been already hinted, from their variety, and from their appropriation to their place and use. They all come from the same blood; they are all drawn off by glands; yet the produce is very different, and the difference exactly adapted to the work which is to be done, or the end to be answered. No account can be given of this, without resorting to appointment. Why, for instance, is the saliva, which is diffused over the seat of taste, insipid, whilst so many others of the secretions, the urine, the tears, and the sweat, are salt? Why does the gland within the ear separate a viscid substance, which defends that passage; the gland in the upper angle of the eye a thin brine, which washes the ball? Why is the synovia of the joints mucilaginous; the bile bitter, stimulating, and soapy? Why does the juice which flows into the stomach contain powers which make that bowel the great laboratory, as it is by its situation the recipient, of the materials of future nutrition? These are all fair questions; and no answer can be given to them but what calls in intelligence and intention.

My object in the present chapter has been to teach three things; first, that it is a mistake to suppose that, in reasoning from the appearances of nature, the imperfection of our knowledge proportionably affects the certainty of our conclusion; for in many cases it does not affect it at all: secondly, that the different parts of the animal frame may be classed and distributed according to the degree of exactness with which we compare them with works of art; thirdly, that the *mechanical* parts of our frame, or those in which this comparison is most complete, although constituting, probably, the coarsest portions of nature's workmanship, are the most proper to be alleged as proofs and specimens of design.

CHAPTER VIII.

OF MECHANICAL ARRANGEMEMT IN THE HUMAN FRAME.

We proceed, therefore, to propose certain examples aken out of this class; making choice of such as, mongst those which have come to our knowledge, ppear to be the most striking and the best undertood; but obliged, perhaps, to postpone both these ecommendations to a third: that of the example eing capable of explanation without plates, or figures, r technical language.

OF THE BONES.

I.—I challenge any man to produce in the joints nd pivots of the most complicated or the most flexible nachine that was ever contrived, a construction more rtificial, or more evidently artificial, than that which s seen in the vertebræ of the *human neck*. Two things vere to be done: the head was to have the power of ending forward and backward, as in the act of nodding, stooping, looking upward or downward; and, at he same time, of turning itself round upon the body o a certain extent—the quadrant, we will say, or raher, perhaps, a hundred and twenty degrees of a cirle. For these two purposes two distinct contrivances re employed: first, the head rests immediately upon he uppermost part of the vertebræ, and is united to it y a *hinge*-joint; upon which joint the head plays freely forward and backward, as far either way as is necessary, or as the ligaments allow; which was the first thing required. But then the rotatory motion is unprovided for: therefore, secondly, to make the head capable of this, a further mechanism is introduced; not between the head and the uppermost bone of the neck, where the hinge is, but between that bone and the bone next underneath it. It is a mechanism resembling a *tenon and mortise*. This second, or uppermost bone but one, has what anatomists call a process, viz. a projection, somewhat similar in size and shape to a tooth; which tooth entering a corresponding hole or socket in the bone above it, forms a pivot or axle, upon which that upper bone, together with the head which it supports, turns freely in a circle; and as far in the circle as the attached muscles permit the head to turn. Thus are both motions perfect without interfering with each other. When we nod the head, we use the hinge-joint, which lies between the head and the neck. When we turn the head round, we use the tenon and mortise, which runs between the first bone of the neck and the second.

We see the same contrivance and the same principle employed in the frame or mounting of a telescope. It is occasionally requisite that the object-end of the instrument be moved up and down, as well as horizontally, or equatorially. For the vertical motion, there is a hinge, upon which the telescope plays; for the horizontal or equatorial motion, an axis upon which the telescope and the hinge turn together. And this is exactly the mechanism which is applied to the motion of the head; nor will any one here doubt of the existence of counsel and design, except it be by that debility of mind which can trust to its own reasonings in nothing.

We may add, that it was, on another account, also expedient that the motion of the head backward and forward should be performed upon the upper surface of the first vertebra; for, if the first vertebra itself had bent forward, it would have brought the spinal marrow, at the very beginning of its course, upon the point of the tooth.

II. Another mechanical contrivance, not unlike the last in its object, but different and original in its means, is seen in what anatomists call the *fore-arm*—that is, in the arm between the elbow and the wrist. Here, for the perfect use of the limb, two motions are wanted: a motion at the elbow, backward and forward, which is called a reciprocal motion; and a rotatory motion, by which the palm of the hand, as occasion requires, may be turned upward. How is this managed? The fore-arm, it is well known, consists of two bones, lying alongside each other, but touching only towards the ends. One, and only one, of these bones is joined to the cubit, or upper part of the arm, at the elbow; the other alone to the hand at the wrist. The first, by means, at the elbow, of a hinge-joint, (which allows only of motion in the same plane,) swings backward and forward, carrying along with it the other bone, and the whole fore-arm. In the meantime, as often as there is occasion to turn the palm upward, that other bone to which the hand is attached rolls upon the first, by the help of a groove or hollow near each end of one bone, to which is fitted a corresponding prominence in the other. If both bones had been joined to the cubit or upper arm, at the elbow, or both to the hand at the wrist, the thing could not have been done. The first was to be at liberty at one end, and the second at the other; by which means the two actions may be performed together. The great bone which carries the fore-arm may be swinging upon its hinge at the elbow at the very time that the lesser bone, which carries the hand, may be turning round it in the grooves. The management, also, of these grooves, or rather of the tubercles and grooves, is very observable. The two bones are called the *radius* and the *ulna*. Above, *i. e.* towards the elbow, a tubercle of the radius plays into a socket of the ulna; whilst below, *i. e.* towards the wrist, the radius finds the socket, and the ulna the tubercle. A single bone in the fore-arm, with a ball and socket-joint at the elbow, which admits of motion in all directions, might, in some degree, have answered the purpose of both moving the arm and turning the hand. But how much better it is accomplished by the present mechanism any person may conceive himself who puts the ease and quickness with which he can shake his hand at the wrist circularly, (moving likewise, if he pleases, his arm at the elbow at the same time,) in competition with the comparatively slow and laborious motion with which his arm can be made to turn round at the shoulder by the aid of a ball and socket-joint.

III. The *spine*, or back-bone, is a chain of joints of very wonderful construction. Various, difficult, and almost inconsistent offices were to be executed by the same instrument. It was to be firm, yet flexible; (now, I know no chain made by art which is both these; for by firmness I mean, not only strength but stability; *firm*, to support the erect position of the body; *flexible*, to allow of the bending of the trunk in all degrees of curvature. It was further also, (which is another and quite a distinct purpose from the rest,) to become a pipe or conduit for the safe conveyance from the brain of the most important fluid of the animal frame, that, namely, upon which all voluntary motion depends, the spinal marrow; a substance not only of the first necessity to action, if not to life, but of a nature so delicate and tender, so susceptible and so impatient of injury, as that any unusual pressure upon it, or any considerable obstruction of its course, is followed by paralysis or death.

Now the spine was not only to furnish the main trunk for the passage of the medullary substance from the brain, but to give out, in the course of its progress, small pipes therefrom, which, being afterwards indefinitely subdivided, might, under the name of nerves, distribute this exquisite supply to every part of the body. The same spine was also to serve another use not less wanted than the preceding, viz. to afford a fulcrum, stay, or basis (or, more properly speaking, a series of these,) for the insertion of the muscles which are spread over the trunk of the body; in which trunk there are not, as in the limbs, cylindrical bones to which they can be fastened: and likewise, which is a similar use to furnish a support for the ends of the ribs to res upon.

Bespeak of a workman a piece of mechanism whicl shall comprise all these purposes, and let him set abou to contrive it; let him try his skill upon it; let hin feel the difficulty of accomplishing the task, before h be told how the same thing is effected in the anima frame. Nothing will enable him to judge so well o the wisdom which has been employed: nothing wil dispose him to think of it so truly. First, for the firm ness, yet flexibility of the spine; it is composed of great number of bones (in the human subject, of twen ty-four,) joined to one another, and compacted by broa bases. The breadth of the bases upon which the part severally rest, and the closeness of the junction, giv to the chain its firmness and stability; the number o parts, and consequent frequency of joints, its flexibility Which flexibility, we may also observe, varies in dif ferent parts of the chain; is least in the back, wher strength more than flexure is wanted; greater in th loins, which it was necessary should be more suppl than the back; and greatest of all in the neck, for th free motion of the head. Then, secondly, in order t afford a passage for the descent of the medullary sub stance, each of these bones is bored through in the mid dle, in such a manner as that, when put together, th hole in one bone falls into a line and corresponds witl the holes in the two bones contiguous to it. By whicl means the perforated pieces, which joined, form an en tire, close, uninterrupted channel, at least whilst th spine is upright and at rest. But as a settled postur

inconsistent with its use, a great difficulty still re-
ained, which was to prevent the vertebræ shifting
oon one another, so as to break the line of the canal
; often as the body moves or twists, or the joints gap-
g externally whenever the body is bent forward and
e spine thereupon made to take the form of a bow.
hese dangers, which are mechanical, are mechani-
lly provided against. The vertebræ, by means of
eir processes and projections, and the articulations
hich some of these form with one another at their
tremities, are so locked in and confined as to main-
in, in what are called the bodies or broad surfaces of
e bones, the relative position nearly unaltered, and
throw the change and the pressure produced by
xion almost entirely upon the intervening cartilages,
e springiness and yielding nature of whose substance
mits of all the motion which is necessary to be per-
med upon them, without any chasm being produced
a separation of the parts. I say, of all the motion
hich is necessary; for although we bend our backs
every degree almost of inclination, the motion of
ch vertebræ is very small: such is the advantage we
ceive from the chain being composed of so many
ks, the spine of so many bones. Had it consisted of
ree or four bones only, in bending the body the spi-
l marrow must have been bruised at every angle.
he reader need not be told that these intervening
rtilages are gristles, and he may see them in perfec-
n in a loin of veal. Their form also favors the
me intention. They are thicker before than behind;
that when we stoop forward, the compressible sub-

stance of the cartilage, yielding in its thicker and a terior part to the force which squeezes it, brings t surface of the adjoining vertebræ nearer to the bei parallel with one another than they were before, inste of increasing the inclination of their planes, whi must have occasioned a fissure or opening betwe them. Thirdly, for the medullary canal giving out its course, and in a convenient order, a supply of nerv to different parts ef the body, notches are made in t upper and lower edge of every vertebræ, two on ea edge, equidistant on each side from the middle line the back. When the vertebræ are put together, the notches, exactly fitting, form small holes, throu which the nerves at each articulation issue out in pai in order to send their branches to every part of the b dy, and with an equal bounty to both sides of the b dy. The fourth purpose assigned to the same instr ment is the insertion of the basis of the muscles, a the support of the ends of the ribs; and for this four purpose, especially the former part of it, a figure sp cifically suited to the design, and unnecessary for t other purposes, is given to the constituent bones. Whi they are plain, and round, and smooth towards t front, where any roughness or projection might ha wounded the adjacent viscera, they run out behin and on each side, into long processes; to which proce ses the muscles necessary to the motions of the tru are fixed, and fixed with such art, that whilst the ve tebræ supply a basis for the muscles, the muscles he to keep these bones in their position, or by their tendo to tie them together. That most important, howev nd general property, viz. the strength of the compages, nd the security against luxation, was to be still more specially consulted; for, where so many joints were oncerned, and where, in every one, derangement ould have been fatal, it became a subject of studious recaution. For this purpose the vertebræ are articuted, that is, the movable joints between them are rmed by means of those projections of their substance hich we have mentioned under the name of processs, and these so lock in with and overwarp one anoer as to secure the body of the vertebra not only from cidentally slipping, but even from being pushed out its place by any violence short of that which would eak the bone. I have often remarked and admired is structure in the chine of a hare. In this, as in any instances, a plain observer of the animal economy may spare himself the disgust of being present at iman dissections, and yet learn enough for his information and satisfaction, by even examining the bones the animals which come upon his table. Let him xe, for example, into his hands a piece of the cleanked bone of a hare's back, consisting, we will suppse, of three vertebræ. He will find the middle bone the three so implicated, by means of its projections processes, with the bone on each side of it, that no essure which he can use will force it out of its place tween them. It will give way neither forward nor ckward, nor on either side. In whichever direction pushes, he perceives, in the form, or junction, or erlapping of the bones, an impediment opposed to attempt, a check and guard against dislocation. In one part o. the spine he will find a still further forti ing expedient, in the mode according to which t vertebræ are annexed to the spine. Each rib rests u on two vertebræ. That is the thing to be remark and any one may remark it in carving a neck of m ton. The manner of it is this: the end of the rib divided by a middle ridge into two surfaces, whi surfaces are joined to the bodies of two contiguous v tebræ, the ridge applying itself to the intervening ca tilage. Now this is the very contrivance which is e ployed in the famous iron bridge at my door at Bis op-Wearmouth, and for the same purpose of stabilit viz. the cheeks of the bars which pass between the arc es ride across the joints by which the pieces composi each arch are united. Each cross-bar rests upon tv of these pieces at their place of junction, and by th position resists, at least in one direction, any tenden in either piece to slip out of its place. Thus perfectl by one means or the other, is the danger of slippi laterally, or of being drawn aside out of the *line* of t back, provided against; and, to withstand the bon being pulled asunder longitudinally, or in the directi of that line, a strong membrane runs from one end the chain to the other, sufficient to resist any for which is likely to act in the direction of the back parallel to it, and consequently to secure the who combination of their places. The general result that not only the motions of the human body necessa for the ordinary offices of life are performed with safet but that it is an incident hardly ever heard of th even the gesticulations of a harlequin distort his spin

Upon the whole, and as a guide to those who may e inclined to carry the consideration of this subject urther, there are three views under which the spine ught to be regarded, and in all which it cannot fail to xcite our admiration. These views relate to its artiulations, its ligaments, and its perforation; and to the orresponding advantages which the body derives from , for action, for strength, and for that which is essenal to every part, a secure communication with the brain.

The structure of the spine is not in general different different animals. In the serpent tribe, however, it considerably varied; but with a strict reference the conveniency of the animal. For, whereas in uadrupeds the number of vertebræ is from thirty to rty, in the serpent it is nearly one hundred and fifty: hereas in men and quadrupeds the surfaces of the ones are flat, and these flat surfaces laid one against e other, and bound tight by sinews; in the serpent, e bones play one within another, like a ball and ocket,* so that they have a free motion upon one anoer in every direction: that is to say, in men and uadrupeds, firmness is more consulted; in serpents, liancy. Yet even pliancy is not obtained at the exense of safety. The back-bone of a serpent, for cohence and flexibility, is one of the most curious pieces animal mechanism with which we are acquainted. he chain of a watch (I mean the chain which passes etween the spring-barrel and the fusee) which aims the same properties, is but a bungling piece of workanship in comparison with that of which we speak.

* Der. Phys. Theol. p. 396.

IV. The reciprocal enlargement and contraction c the *chest* to allow for the play of the lungs, depend upon a simple yet beautiful mechanical contrivanc referable to the structure of the bones which enclos it. The ribs are articulated to the back-bone, or rathe to its side projections, *obliquely:* that is, in their natu ral position they bend or slope from the place of art culation downwards. But the basis upon which the rest at this end being fixed, the consequence of th obliquity, or the inclination downwards, is, that whe they come to move, whatever pulls the ribs upward necessarily, at the same time, draws them out; an that, whilst the ribs are brought to a right angle wit the spine behind, the sternum, or part of the chest t which they are attached in front, is thrust forward The simple action, therefore, of the elevated muscle does the business; whereas, if the ribs had been arti culated with the bodies of the vertebræ at right angle the cavity of the thorax could never have been furthe enlarged by a change of their position. If each rib ha been a rigid bone, articulated at both ends to fixe bases, the whole chest had been immovable. Keil has observed that the breast-bone, in an easy inspira tion, is thrust into one-tenth of an inch; and he calcu lates that this, added to what is gained to the spac within the chest by the flattening or descent of th diaphragm, leaves room for forty-two cubic inches o air to enter at every drawing-in of the breath. Whe there is a necessity for a deeper and more laboriou inspiration, the enlargement of the capacity of th chest may be so increased by effort, as that the lung

nay be distended with seventy or a hundred such cu-
ɔic inches.* The thorax, says Schelhammer, forms a
kind of bellows, such as never have been, nor probably
will be, made by any artificer.

V. The *patella*, or knee-pan, is a curious little bone: n its form and office unlike any other bone in the body. It is circular; the size of a crown-piece; pretty hick; a little convex on both sides, and covered with ι smooth cartilage. It lies upon the front of the knee: ınd the powerful tendons, by which the leg is brought ɔrward, pass through it (or rather it makes a part f their continuation,) from their origin in the thigh ɔ their insertion in the tibia. It protects both the endon and the joint from any injury which either night suffer, by the rubbing of one against the other, r by the pressure of unequal surfaces. It also gives to ıe tendons a very considerable mechanical advantage, y altering the line of their direction, and by advancing further out from the centre of motion; and this upon ıe principles of the resolution of force, upon which rinciples all machinery is founded. These are its ses. But what is most observable in it is, that it ppears to be supplemental, as it were, to the frame: lded, as it should almost seem, afterward; not quite ecessary, but very convenient. It is separate from the her bones: that is, it is not connected with any other ɔnes by the common mode of union. It is soft, or ardly formed, in infancy; and produced by an ossifiation, of the inception, or progress of which no account

* Anat. p. 229.

can be given from the structure or exercise of the pa

VI. The *shoulder-blade* is, in some material re pects, a very singular bone, appearing to be made expressly for its own purpose, and so independent of every other reason. In such quadrupeds as ha no collar-bones, which are by far the greater numb the shoulder-blade has no bony communication wi the trunk, either by a joint, or process, or in any oth way. It does not grow to, or out of, any other bo in the trunk—(I know not whether this be true of a second bone in the body, except perhaps the os hyoïd —in strictness, it forms no part of the skeleton. It bedded in the flesh, attached only to the muscles. is no other than a foundation bone of the arm, laid separate as it were, and distinct from the general os fication. The lower limbs connect themselves at t hip with bones, which form part of the skeleton; b this connection in the upper limbs being wanting, basis, whereupon the arm might be articulated, was be supplied by a detached ossification for the purpo

OF THE JOINTS.

I. The above are a few examples of bones ma remarkable by their configuration; but to almost the bones belong *joints;* and in these, still more cle ly than the form or shape of the bones themselves, a seen both contrivance and contriving wisdom. Eve joint is a curiosity, and is also strictly mechanic There is the hinge-joint and the mortice and teno joint; each as manifestly such, and as accurately d fined, as any which can be produced out of a cabin maker's shop; and one or the other prevails, as either is adapted to the motion which is wanted—*e. g.* a mortice and tenon, or ball and socket-joint, is not required at the knee, the leg standing in need only of a motion backward and forward in the same plane, for which a hinge-joint is sufficient; a mortice and tenon, or ball and socket-joint is wanted at the hip, that not only the progressive step may be provided for, but the interval between the limbs may be enlarged or contracted at pleasure. Now observe what would have been the inconveniency—*i. e.* both the superfluity and the defect of articulation, if the case had been inverted: if the ball and socket-joint had been at the knee, and the hinge-joint at the hip. The thighs must have been kept constantly together, and the legs had been loose and straddling. There would have been no use, that we know of, in being able to turn the calves of the legs before; and there would have been great confinement by restraining the motion of the thighs to one plane. The disadvantage would not have been less if the joints at the hip and the knee had been both of the same sort; both balls and sockets, or both hinges: yet why, independently of utility, and of a Creator who consulted that utility, should the same bone (the thigh bone) be rounded at one end, and channelled at the other?

The *hinge-joint* is not formed by a bolt passing through the two parts of the hinge, and thus keeping them in their places, but by a different expedient. A strong, tough, parchment-like membrane, rising from the receiving bones, and inserted all round the received bones a little below their heads, encloses the joint o every side. This membrane ties, confines, and hold the ends of the bones together, keeping the corre ponding parts of the joints—*i. e.* the relative conve ties and concavities—in close application to each othe

For the *ball and socket-joint*, beside the membra already described, there is in some important joints, an additional security, a short, strong, yet flexible gament, inserted by one end into the head of the ba by the other into the bottom of the cup, which lig ment keeps the two parts of the joint so firmly in the place, that none of the motions which the limb nat rally performs, none of the jirks and twists to which is ordinarily liable, nothing less indeed than the utmo and the most unnatural violence, can pull them asu der. It is hardly imaginable, how great a force is n cessary, even to stretch, still more to break, this lig ment: yet so flexible is it, as to oppose no impedime to the suppleness of the joint. By its situation also is inaccessible to injury from sharp edges. As it ca not be ruptured, (such is its strength,) so it cannot b cut, except by an accident which would sever the limb If I had been permitted to frame a proof of contrivanc such as might satisfy the most distrustful inquirer, know not whether I could have chosen an example o mechanism more unequivocal or more free from objec tion, than this ligament. Nothing can be more me chanical; nothing, however subservient to the safety less capable of being generated by the action of th joint. I would particularly solicit the reader's atten tion to this provision, as it is found in the head of th *thigh-bone:* to its strength, its structure and its use. It is an instance upon which I lay my hand. One single fact, weighed by a mind in earnest, leaves oftentimes the deepest impression. For the purpose of addressing different understandings and different apprehensions—for the purpose of sentiment—for the purpose of exciting admiration of the Creator's works, we diversify our views, and multiply our examples: but for the purpose of strict argument, one clear instance is sufficient; and not only sufficient, but capable perhaps of generating a firmer assurance than what can arise from a divided attention.

The *ginglymus*, or hinge-joint, does not, it is manifest, admit of a ligament of the same kind with that of the ball and socket-joint; but it is always fortified by the species of ligament of which it does admit. The strong, firm, investing membrane, above described, accompanies it in every part; and in particular joints, this membrane, which is properly a ligament, is considerably stronger on the sides than either before or behind, in order that the convexities may play true in their concavities, and not be subject to slip sideways, which is the chief danger; for the muscular tendons generally restrain the parts from going further than they ought to go in the plane of their motion. In the *knee*, which is a joint of this form, and of great importance, there are superadded to the common provisions for the stability of the joint, two strong ligaments, which cross each other—and cross each other in such a manner as to secure the joint from being displaced in any assignable direction. "I think," says Cheselden, "that the knee cannot be completely dislocated without breaking the *cross* ligaments."* We can hardly help comparing this with the binding up of a fracture where the fillet is almost wholly strapped across, for the sake of giving firmness and strength to the bandage.

Another no less important joint, and that also of the ginglymus sort, is the *ankle*; yet though important, (in order, perhaps, to preserve the symmetry and lightness of the limb,) *small*, and, on that account, more liable to injury. Now this joint is strengthened—*i. e.* is defended from dislocation by two remarkable processes or prolongations of the bones of the leg, which processes form the protuberances that we call the inner and outer ankle. It is part of each bone going down lower than the other part, and thereby overlapping the joint: so that if the joint be in danger of slipping outward, it is curbed by the inner projection—*i. e.* that of the tibia; if inward, by the outer projection—*i. e.* that of the fibula. Between both, it is locked in its position. I know no account that can be given of this structure, except its utility. Why should the tibia terminate at its lower extremity, with a double end, and the fibula the same—but to barricade the joint on both sides by a continuation of part of the thickest of the bone over it? The joint at the *shoulder*, compared with the joint at the *hip*, though both ball and socket-joints, discovers a difference in their form and proportions, well suited to the different offices which the limbs have to execute. The cup or socket at the shoulder is much shallower and

* Ches. Anat. ed. 7th, p. 45.

flatter than it is at the hip, and is also in part formed of cartilage set round the rim of the cup. The socket, into which the head of the thigh-bone is inserted, is deeper, and made of more solid materials. This agrees with the duties assigned to each part. The arm is an instrument of motion, principally, if not solely. Accordingly, the shallowness of the socket at the shoulder, and the yieldingness of the cartilaginous substance with which its edge is set round, and which in fact composes a considerable part of its concavity, are excellently adapted for the allowance of a free motion and a wide range, both which the arm wants. Whereas, the lower limb, forming a part of the column of the body—having to support the body, as well as to be the means of its locomotion—firmness was to be consulted as well as action. With a capacity for motion, in all directions indeed, as at the shoulder, but not in any direction to the same extent as in the arm, was to be united stability, or resistance to dislocation. Hence the deeper excavation of the socket, and the presence of a less proportion of cartilage upon the edge.

The suppleness and pliability of the joints we every moment experience; and the *firmness* of animal articulation, the property we have hitherto been considering, may be judged of from this single observation, that, at any given moment of time, there are millions of animal joints in complete repair and use, for one that is dislocated; and this, notwithstanding the contortions and wrenches to which the limbs of animals are continually subject.

II. The *joints*, or rather the ends of the bones which form them, display also, in their configuration, another use. The nerves, blood-vessels, and tendons, which are necessary to the life, or for the motion of the limbs, must, it is evident, in their way from the trunk of the body to the place of their destination, travel over the movable joints; and it is no less evident that, in this part of their course, they will have, from sudden motions, and from abrupt changes of curvature, to encounter the danger of compression, attrition, or laceration. To guard fibres so tender against consequences so injurious, their path is in those parts protected with peculiar care; and that by a provision in the figure of the bones themselves. The nerves which supply the *fore-arm*, especially the inferior cubital nerves, are at the elbow conducted, by a kind of covered way, between the condyls, or rather under the inner extuberances of the bone which composes the upper part of the arm.* At the *knee*, the extremity of the thigh-bone is divided by a sinus, or cliff, into two heads or protuberances; and these heads on the back-part stand out beyond the cylinder of the bone. Through the hollow which lies between the hind-parts of these two heads—that is to say, under the ham, between the ham-strings, and within the concave recess of the bone formed by the extuberances on each side—in a word, along a defile, between rocks, pass the great vessels and nerves which go to the leg.† Who led these vessels by a road so defended and secured? In the joint at the *shoulder*, in the edge of the cup which receives the head of the

* Ches. Anat. p. 255, ed. 7. † Ibid, p. 35.

›one, is a *notch*, which is joined or covered at the op with a ligament. Through this hole, thus guard-d, the blood-vessels steal to their destination in the arm nstead of mounting over the edge of the concavity.*

III. In all joints, the end of the bones, which work gainst each other, are tipped with *gristle*. In the ball nd socket-joint, the cup is lined and the ball capped vith it. The smooth surface, the elastic and unfriable ature of cartilage, render it of all substances the nost proper for the place and purpose. I should, there-ore, have pointed this out amongst the foremost of the rovisions which have been made in the joints for the acilitating of their action, had it not been alleged, that artilage in truth is only nascent or imperfect bone; nd that the bone in these places is kept soft and im-erfect, in consequence of a more complete and rigid ssification being prevented from taking place by the ontinual motion and rubbing of the surfaces; which eing so, what we represent as a designed advantage s an unavoidable effect. I am far from being con-inced that this is a true account of the fact; or that, f it were so, it answers the argument. To me the urmounting of the bones with gristle looks more ike a plating with a different metal, than like the ame metal kept in a different state by the action o which it is exposed. At all events, we have a great articular benefit, though arising from a general con-titution; but this last, not being quite what my argu-nent requires, lest I should seem by applying the in-

* Ches. Anat. p. 30.

stance to overrate its value, I have thought it fair t state the question which attends it.

IV. In some joints, very particularly in the knee there are loose cartilages or gristles between the bone and within the joint, so that the ends of the bones, in stead of working upon one another, work upon the in termediate cartilages. Cheselden has observed,* tha the contrivance of a loose ring is practised by mecha nics where the friction of the joints of any of their ma chines is great, as between the parts of crook-hinge of large gates, or under the head of the male screv of large vices. The cartilages of which we speak hav very much of the form of these rings. The compari son, moreover, shows the reason why we find them in the knees rather than in other joints. It is an expedi ent, we have seen, which a mechanic resorts to only when some strong and heavy work is to be done. So here the thigh-bone has to achieve its motion at th knee, with the whole weight of the body pressing upon it, and often, as in rising from our seat, with the whole weight of the body to lift. It should seem also, from Cheselden's account, that the slipping and sliding of the loose cartilages, though it be probably a small and obscure change, humored the motion at the end of the thigh-bone, under the particular configuration which was necessary to be given to it for the commodious action of the tendons (and which configuration requires what he calls a variable socket, that is, a concavity, the lines of which assume a different curvature in different inclinations of the bones.)

* Ches. Anat. p. 13, ed. 7.

V. We have now done with the configuration: but there is also in the joints, and that common to them all, another exquisite provision manifestly adapted to their use, and concerning which there can, I think, be no dispute, namely, the regular supply of a *mucilage*, more emollient and slippery than oil itself, which is constantly softening and lubricating the parts that rub upon each other, and thereby diminishing the effect of attrition in the highest possible degree. For the continual secretion of this important liniment, and for the feeding of the cavities of the joint with it, glands are fixed near each joint, the excretory ducts of which glands, dripping with their balsamic contents, hang loose like fringes within the cavity of the joints. A late improvement in what are called friction wheels, which consists of a mechanism so ordered as to be regularly dropping oil into a box which encloses the axis, the nave, and certain balls upon which the nave revolves, may be said, in some sort, to represent the contrivance in the animal joint, with this superiority, however, on the part of the joint, viz. that here the oil is not only dropped, but *made*.

In considering the joints, there is nothing, perhaps, which ought to move our gratitude more than the reflection, *how well they wear*. A limb shall swing upon its hinge, or play in its socket, many hundred times in an hour, for sixty years together, without diminution of its agility, which is a long time for anything to last—for anything so much worked and exercised as the joints are. This durability I should attribute in part to the provision which is made for the preventing of wear and tear, first by the polish of the cartilagi-nous surfaces; secondly, by the healing lubrication of the mucilage, and, in part, to that astonishing proper-ty of animal constitutions, assimilation, by which, in every portion of the body, let it consist of what it will, substance is restored, and waste repaired.

Movable joints, I think, compose the curiosity of bones; but their union, even where no motion is in-tended or wanted, carries marks of mechanism and of mechanical wisdom. The teeth, especially the front teeth, are one bone fixed in another, like a peg driven into a board. The sutures of the skull are like the edges of two saws clapped together in such a manner as that the teeth of one enter the intervals of the other. We have sometimes one bone lapping over another, and planed down at the edges; sometimes also the thin lamella of one bone received into a narrow furrow of another. In all which varieties we seem to discover the same design, viz. firmness of juncture without clumsiness in the seam.

CHAPTER IX.

OF THE MUSCLES.

Muscles, with their tendons, are the instruments by which animal motion is performed. It will be our bu-siness to point out instances in which, and properties with respect to which, the disposition of these muscles is as strictly mechanical as that of the wires and strings of a puppet.

I. We may observe, what I believe is universal, an exact relation between the joint and the muscles which move it. Whatever motion the joint, by its mechanical construction, is capable of performing, that motion the annexed muscles, by their position, are capable of producing. For example, if there be, as in the knee and elbow, a hinge-joint, capable of motion only in the same plane, the leaders, as they are called, *i. e.* the muscular tendons, are placed in directions parallel to the bone, so as, by the contraction or relaxation of the muscles to which they belong, to produce that motion and no other. If these joints were capable of a freer motion, there are no muscles to produce it. Whereas, at the shoulder and hip, where the ball and socket-joint allows by its construction of a rotatory or sweeping motion, tendons are placed in such a position, and pull in such a direction, as to produce the motion of which the joint admits. For instance, the sartorius or tailor's muscle, rising from the spine, running diagonally across the thigh, and taking hold of the inside of the main bone of the leg a little below the knee, enables us, by its contraction, to throw one leg and thigh over the other, giving effect at the same time, to the ball and socket-joint at the hip, and the hinge-joint at the knee. There is, as we have seen, a specific mechanism in the bones for the rotatory motions of the head and hands: there is, also, in the oblique direction of the muscles belonging to them, a specific provision for the putting of this mechanism of the bones into action. And mark the consent of uses: the oblique muscles would have been inefficient without that particular articulation; that particular articulation would have been lost without the oblique muscles. It may be proper, however, to observe, with respect to the *head*, although I think it does not vary the case, that its oblique motions and inclinations are often motions in a *diagonal* produced by the joint action of muscles lying in straight directions. But whether the pull be single or combined, the articulation is always such as to be capable of obeying the action of the muscles. The oblique muscles attached to the head are likewise so disposed as to be capable of steadying the globe as well as of moving it. The head of a new-born infant is often obliged to be filleted up. After death, the head drops and rolls in every direction. So that it is by the equilibre of the muscles, by the aid of a considerable and equipollent muscular force in constant exertion, that the head maintains its erect posture. The muscles here supply what would otherwise be a great defect in the articulation; for the joint in the neck, although admirably adapted to the motion of the head, is insufficient for its support. It is not only by the means of a most curious structure of the bones that a man turns his head, but by virtue of an adjusted muscular power that he even holds it up.

As another example of what we are illustrating, viz. conformity of use between the bones and the muscles, it has been observed of the different vertebræ, that their processes are exactly proportioned to the quantity of motion which the other bones allow of, and which the respective muscles are capable of producing.

II. A muscle acts only by contraction. Its force is exerted in no other way. When the exertion ceases, it relaxes itself; that is, it returns by relaxation to its former state, but without energy. This is the nature of the muscular fibre; and being so, it is evident that the reciprocal *energetic* motion of the limbs, by which we mean motion *with force* in opposite directions, can only be produced by the instrumentality of opposite or antagonist muscles—of flexors and extensors answering to each other. For instance, the biceps and brachialis *internus* muscles placed in the front part of the upper arm, by their contraction, bend the elbow, and with such degree of force as the case requires or the strength admits of. The relaxation of these muscles after the effort would merely let the forearm drop down. For the *back stroke*, therefore, and that the arm may not only bend at the elbow, but also extend and straighten itself with force, other muscles, the longus and brevis brachialis *externus*, and the anconæus, placed on the hinder part of the arms, by their contractile twitch, fetch back the forearm into a straight line with the cubit, with no less force than that with which it was bent out of it. The same thing obtains in all the limbs, and in every movable part of the body. A finger is not bent and straightened without the *contraction* of two muscles taking place. It is evident, therefore, that the animal functions require that particular disposition of the muscles which we describe by the name of antagonist muscles. And they are accordingly so disposed. Every muscle is provided with an adversary. They act like two sawyers in a pit, by an opposite pull; and nothing, surely, can more strongly indicate design and attention to an end than their being thus stationed, than this collocation. The nature of the muscular fibre being what it is, the purposes of the animal could be answered by no other. And not only the capacity for motion, but the aspect and symmetry of the body is preserved by the muscles being marshalled according to this order—*e. g.* the mouth is holden in the middle of the face, and its angles kept in a state of exact correspondency, by two muscles drawing against and balancing each other. In a hemiplegia, when the muscle on one side is weakened, the muscle on the other side draws the mouth awry.

III. Another property of the muscles, which could only be the result of care, is, their being almost universally so disposed as not to obstruct or interfere with one another's action. I know but one instance in which this impediment is perceived. We cannot easily swallow whilst we gape. This, I understand, is owing to the muscles employed in the act of deglutition being so implicated with the muscles of the lower jaw, that whilst these last are contracted, the former cannot act with freedom. The obstruction is, in this instance, attended with little inconvenience; but it shows what the effect is where it does exist; and what loss of faculty there would be if it were more frequent. Now, when we reflect upon the number of muscles, not fewer than four hundred and forty-six, in the human body, known and named,* how contiguous they lie to each other, in layers, as it were, over one another, crossing one another, sometimes embedded in one another, sometimes perforating one another —an arrangement which leaves to each its liberty, and its full play, must necessarily require meditation and counsel.

IV. The following is oftentimes the case with the muscles. Their action is wanted where their situation would be inconvenient. In which case the body of the muscle is placed in some commodious position at a distance, and made to communicate with the point of action by slender strings or wires. If the muscles which move the fingers had been placed in the palm or back of the hand, they would have swelled that part to an awkward and clumsy thickness. The beauty, the proportions of the part would have been destroyed. They are therefore disposed in the arm, and even up to the elbow, and act by long tendons strapped down at the wrist, and passing under the ligaments to the fingers, and to the joints of the fingers which they are severally to move. In like manner, the muscles which move the toes and many of the joints of the foot, how gracefully are they disposed in the calf of the leg, instead of forming an unwieldy tumefaction in the foot itself! The observation may be repeated of the muscle which draws the nictitating membrane over the eye. Its office is in the front of the eye; but its body is lodged in the back part of the

* Keill's Anatomy, p. 295, ed. 3.

globe, where it lies safe, and where it encumbers nothing.

V. The great mechanical variety in the figure of the muscles may be thus stated. It appears to be a fixed law that the contraction of a muscle shall be towards its centre. Therefore the subject for mechanism on each occasion is, so to modify the figure and adjust the position of the muscle as to produce the motion required agreeably with this law. This can only be done by giving to different muscles a diversity of configuration suited to their several offices, and to their situation with respect to the work which they have to perform. On which account we find them under a multiplicity of forms and attitudes; sometimes with double, sometimes with treble tendons, sometimes with none: sometimes one tendon to several muscles, at other times one muscle to several tendons. The shape of the organ is susceptible of an incalculable variety, whilst the original property of the muscle, the law and line of its contraction, remains the same, and is simple. Herein the muscular system may be said to bear a perfect resemblance to our works of art. An artist does not alter the native quality of his materials, or their laws of action. He takes these as he finds them. His skill and ingenuity are employed in turning them, such as they are, to his account, by giving to the parts of his machine a form and relation in which these unalterable properties may operate to the production of the effects intended.

VI. The ejaculations can never too often be repeated—How many things must go right for us to be an ıour at ease! how many more for us to be vigorous .nd active! Yet vigor and activity are, in a vast plu- ality of instances, preserved in human bodies, not- vithstanding that they depend upon so great a number f instruments of motion, and notwithstanding that the .efect or disorder sometimes of a very small instru- ıent, of a single pair, for instance, out of the four hun- red and forty-six muscles which are employed, may e attended with grievous inconveniency. There is iety and good sense in the following observation ta- en out of the "Religious Philosopher:" "With much ompassion," says the writer, "as well as astonishment t the goodness of our loving Creator, have I considered ıe sad state of a certain gentleman, who, as to the ›st, was in pretty good health, but only wanted the se of these *two little muscles* that serve to lift the yelids, and so had almost lost the use of his sight, eing forced, as long as this defect lasted, to shove up is eyelids every moment with his own hands!" In eneral we may remark in how small a degree those ho enjoy the perfect use of these organs know the omprehensiveness of the blessing, the variety of their bligation. They perceive a result, but they think ttle of the multitude of concurrences and rectitudes hich go to form it.

Besides these observations, which belong to the ıuscular organ as such, we may notice some advan- ıges of structure which are more conspicuous in ıuscles of a certain class or description than in others. 'hus:

I. The variety, quickness, and precision of which muscular motion is capable are seen, I think, in n part so remarkably as in the *tongue.* It is worth an man's while to watch the agility of his tongue, th wonderful promptitude with which it executes change of position, and the perfect exactness. Each syllabl of articulated sound requires for its utterance a specifi action of the tongue, and of the parts adjacent to i The disposition and configuration of the mouth apper taining to every letter and word, is not only peculia but, if nicely and accurately attended to, perceptible t the sight; insomuch, that curious persons have availe themselves of this circumstance to teach the deaf t speak, and to understand what is said by others. I the same person, and after his habit of speaking i formed, one, and only one position of the parts wi produce a given articulate sound correctly. How in stantaneously are these positions assumed and dismiss ed! how numerous are the permutations, how vari ous, yet how infallible! Arbitrary and antic variet is not the thing we admire; but variety obeying a rule conducing to an effect, and commensurate with exi gencies infinitely diversified. I believe also that th anatomy of the tongue corresponds with these obser vations upon its activity. The muscles of the tongue are so numerous, and so implicated with one another that they cannot be traced by the nicest dissection nevertheless, (which is a great perfection of the organ, neither the number, nor the complexity, nor wha might seem to be the entanglement of its fibres, in any wise impede its motion, or render the determination o success of its efforts uncertain.

I here entreat the reader's permission to step a little out of my way, to consider *the parts of the mouth* in some of their other properties. It has been said, and that by an eminent physiologist, that, whenever nature attempts to work two or more purposes by one instrument, she does both or all imperfectly. Is this true of the tongue, regarded as an instrument of speech and of taste, or regarded as an instrument of speech, of taste, and of deglutition? So much otherwise, that many persons, that is to say nine hundred and ninety-nine persons out of a thousand, by the instrumentality of this one organ. talk, and taste, and swallow very well. In fact, the constant warmth and moisture of the tongue, the thinness of the skin, the papillæ upon its surface, qualify this organ for its office of tasting, as much as its inextricable multiplicity of fibres do for the rapid movements which are necessary to speech. Animals which feed upon grass have their tongues covered with a perforated skin, so as to admit the dissolved food to the papillæ underneath, which, in the meantime, remain defended from the rough action of the unbruised spiculæ.

There are brought together within the cavity of the mouth more distinct uses, and parts executing more distinct offices, than I think can be found lying so near one another, or within the same compass, in any other portion of the body: viz. teeth of different shape, first for cutting, secondly for grinding; muscles, most artificially disposed for carrying on the compound motion of the lower jaw, half lateral and half vertical, by which the mill is worked: fountains of saliva, spring-ing up in different parts of the cavity for the moistening of the food while the mastication is going on: glands, to feed the fountains; a muscular constriction of a very peculiar kind in the back part of the cavity, for the guiding of the prepared aliment into its passage towards the stomach, and in many cases for carrying it along that passage; for, although we may imagine this to be done simply by the weight of the food itself, it in truth is not so, even in the upright posture of the human neck; and most evidently is not the case with quadrupeds—with a horse, for instance, in which, when pasturing, the food is thrust upwards by muscular strength instead of descending of its own accord.

In the mean time, and within the same cavity, is going on another business, altogether different from what is here described—that of respiration and speech. In addition, therefore, to all that has been mentioned, we have a passage opened from this cavity to the lungs, for the admission of air exclusively of every other substance: we have muscles, some in the larynx, and without number in the tongue, for the purpose of modulating that air in its passage, with a variety, a compass, and precision, of which no other musical instrument is capable. And lastly, which, in my opinion, crowns the whole as a piece of machinery, we have a specific contrivance for dividing the pneumatic part from the mechanical, and for preventing one set of actions interfering with the other. Where various functions are united, the difficulty is to guard against the inconveniencies of a too great complexity. In no apparatus put together by art and for the purposes of art, do I know such multifarious uses so aptly combined, as in the natural organization of the human mouth; or where the structure, compared with the uses, is so simple. The mouth, with all these intentions to serve, is a single cavity; is one machine; with its parts neither crowded nor confused, and each unembarrassed by the rest: each at least at liberty in a degree sufficient for the end to be attained. If we cannot eat and sing at the same moment, we can eat one moment and sing the next; the respiration proceeding freely all the while.

There is one case, however, of this double office, and that of the *earliest* necessity, which the mouth alone could not perform; and that is, carrying on together the two actions of sucking and breathing. Another route therefore is opened for the air—namely, through the nose—which lets the breath pass backward and forward, whilst the lips, in the act of sucking, are necessarily shut close upon the body from which the nutriment is drawn. This is a circumstance which always appeared to me worthy of notice. The nose would have been necessary, although it had not been the organ of smelling. The making it the seat of a sense was superadding a new use to a part already wanted; was taking a wise advantage of an antecedent and a constitutional necessity.

But to return to that which is the proper subject of the present section—the celerity and precision of muscular motion. These qualities may be particularly observed in the execution of many species of instrumental *music*, in which the changes produced by the hand of the musician are exceedingly rapid; are exactl measured, even when most minute; and display, o the part of the muscles, an obedience of action alik wonderful for its quickness and its correctness.

Or let a person only observe his own hand whil he is *writing;* the number of muscles which ar brought to bear upon the pen; how the joint and ad justed operation of several tendons is concerned i every stroke, yet that five hundred such strokes ar drawn in a minute. Not a letter can be turned withou more than one, or two, or three tendinous contraction definite, both as to the choice of the tendon, and as t the space through which the contraction moves; ye how currently does the work proceed! and when w look at it, how faithful have the muscles been to thei duty—how true to the order which endeavor or habi hath inculcated! For let it be remembered, that, whils a man's hand-writing is the same, an exactitude of or der is preserved, whether he write well or ill. Thes two instances of music and writing show not only th quickness and precision of muscular action, but th docility.

II. Regarding the particular configuration of mus cles, *sphincter* or circular muscles appear to be admi rable pieces of mechanism. It is the muscular powe most happily applied; the same quality of the muscu lar substance, but under a new modification. The cir cular disposition of the fibres is strictly mechanical but, though the most mechanical, is not the only thing in sphincters which deserves our notice. The regula ted degree of contractile force with which they are endowed, sufficient for retention, yet vincible when requisite, together with their ordinary state of actual contraction, by means of which their dependence upon the will is not constant but occasional, gives to them a constitution of which the conveniency is inestimable. This their semi-voluntary character is exactly such as suits with the wants and functions of the animal.

III. We may also, upon the subject of muscles, observe, that many of our most important actions are achieved by the combined help of different muscles. Frequently a diagonal motion is produced by the contraction of tendons pulling in the direction of the sides of the parallelogram. This is the case, as has been already noticed, with some of the oblique nutations of the head. Sometimes the number of co-operating muscles is very great. Dr. Nieuentyt, in the Leipsic Transactions, reckons up a hundred muscles that are employed every time we breathe; yet we take in, or let out our breath without reflecting what a work is thereby performed; what an apparatus is laid in of instruments for the service, and how many such contribute their assistance to the effect. Breathing with ease is a blessing of every moment; yet of all others it is that which we possess with the least consciousness. A man in an asthma is the only man who knows how to estimate it.

IV. Mr. Home has observed,* that the most important and the most delicate actions are performed in the body by the smallest muscles; and he mentions, as

* Phil. Trans. part i, 1800, p. 8.

his examples, the muscles which have been discovere in the iris of the eye, and the drum of the ear. Th tenuity of these muscles is astonishing: they are mi croscopic hairs; must be magnified to be visible; ye are they real effective muscles: and not only such, bu the grandest and most precious of our faculties, sigh and hearing depend upon their health and action.

V. The muscles act in the limbs with what is called mechanical disadvantage. The muscle at the shoulde by which the arm is raised, is fixed nearly in the sam manner as the load is fixed upon a steelyard, within few decimals, we will say, of an inch from the centr upon which the steelyard turns. In this situation, w find that a very heavy draught is no more than suffi cient to countervail the force of a small lead plumme placed upon the long arm of the steelyard, at the dis tance of perhaps fifteen or twenty inches from the cen tre and on the other side of it. And this is the disad vantage which is meant; and an absolute disadvan tage, no doubt, it would be, if the object were to spar the force of muscular contraction. But observe hov conducive is this constitution to animal conveniency Mechanism has always in view one or other of thes two purposes—either to move a great weight slowly and through a small space, or to move a light weigh rapidly, through a considerable sweep. For the for mer of these purposes a different species of lever, and different collocation of the muscles, might be better tha the present; but for the second, the present structur is the true one. Now so it happens, that the secon and not the first, is that which the occasions of anima life principally call for. In what concerns the human body, it is of much more consequence to any man to be able to carry his hand to his head with due expedition, than it would be to have the power of raising from the ground a heavier load (of two or three more hundred weight, we will suppose) than he can lift at present. This last is a faculty, which, on some extraordinary occasions, he may desire to possess; but the other is what he wants and uses every hour or minute. In like manner, a husbandman or a gardener will do more execution, by being able to carry his scythe, his rake, or his flail, with a sufficient dispatch through a sufficient space, than if, with greater strength, his motions were proportionably more confined and slow. It is the same with a mechanic in the use of his tools. It is the same also with other animals in the use of their limbs. In general, the vivacity of their motions would be ill exchanged for greater force under a clumsier structure.

We have offered our observations upon the structure of muscles in general; we have also noticed certain species of muscles; but there are also *single* muscles which bear marks of mechanical contrivance appropriate as well as particular. Out of many instances of this kind we select the following:—

I. Of muscular actions, even of those which are well understood, some of the most curious are incapable of popular explanation; at least without the aid of plates and figures. This is in a great measure the case with a very familiar, but, at the same time, a very complicated motion, that of the *lower jaw;* and with the muscular structure by which it is produced. One of the muscles concerned may, however be described i such a manner as to be, I think, sufficiently compr hended for our present purpose. The problem is pull the lower jaw *down.* The obvious method shoul seem to be, to place a straight muscle—viz. to fix string from the chin to the breast, the contraction c which would open the mouth, and produce the motio required at once. But it is evident that the form an liberty of the neck forbid a muscle being laid in suc a position; and that, consistently with the preservatio of this form, the motion which we want must be e fectuated by some muscular mechanism disposed fu ther back in the jaw. The mechanism adopted is a follows:—A certain muscle, called the *digastric*, rise on the side of the face, considerably *above* the inse tion of the lower jaw, and comes down, being conver ed in its progress into a round tendon. Now it i manifest that the tendon, whilst it pursues a directio *descending* towards the jaw, must, by its contractio pull the jaw up instead of down. What then was t be done? This, we find, is done: The descendin tendon, when it is got low enough, is passed throug a loop, or ring, or pully, in the os hyoides, and the made to ascend; and having thus changed its line o direction, is inserted into the inner part of the chin by which device, viz. the turn at the loop, the actio of the muscle, (which in all muscles is contraction, that before would have pulled the jaw up, now as ne cessarily draws it down. "The mouth," says Heiste "is opened by means of this trochlea in a most won derful and elegant manner."

II. What contrivance can be more mechanical than the following, viz. a slit in one tendon to let another tendon pass through it? This structure is found in the tendons which move the toes and fingers. The long tendon, as it is called, in the foot, which bends the first joint of the toe, passes *through* the short tendon which bends the second joint, which course allows to the sinew more liberty, and a more commodious action than it would otherwise have been capable of exerting.* There is nothing, I believe, in a silk or cotton mill, in the belts, or straps, or ropes, by which motion is communicated from one part of the machine to another, that is more artificial. or more evidently so, than this *perforation.*

III. The next circumstance which I shall mention under this head of muscular arrangement is so decisive a mark of intention, that it always appeared to me to supersede, in some measure, the necessity of seeking for any other observation upon the subject; and that circumstance is, the tendons which pass from the leg to the foot, being bound down by a ligament to the ankle. The foot is placed at a considerable angle with the leg. It is manifest, therefore, that flexible strings, passing along the interior of the angle, if left to themselves, would, when stretched, start from it. The obvious preventive is to tie them down. And this is done in fact. Across the instep, or rather just above it, the anatomist finds a strong ligament, *under* which the tendons pass to the foot. The effect of the ligament

* Ches. Anat. p. 119.

as a bandage can be made evident to the senses; for if it be cut, the tendons start up. The simplicity, yet the clearness of this contrivance, its exact resemblance to established resources of art, place it amongst the most indubitable manifestations of design with which we are acquainted.

There is also a further use to be made of the present example, and that is, as it precisely contradicts the opinion that the parts of animals may have been all formed by what is called *appetency*, *i. e.* endeavor perpetuated and imperceptibly working its effect through an incalculable series of generations. We have here no endeavor, but the reverse of it—a constant renitency and reluctance. The endeavor is all the other way. The pressure of the ligament constrains the tendons; the tendons re-act upon the pressure of the ligament. It is impossible that the ligament should ever have been generated by the exercise of the tendon or in the course of that exercise, forasmuch as the force of the tendon perpendicularly resists the fibre which confines it, and is constantly endeavoring, not to form, but to rupture and displace the threads of which the ligament is composed.

Keill has reckoned up in the human body four hundred and forty-six muscles, dissectible and describable; and hath assigned a use to every one of the number. This cannot be all imagination.

Bishop Welkins hath observed from Galen, that there are at least ten several qualifications to be attended to in each particular muscle—viz. its proper figure; its just magnitude; its fulcrum; its point of action, supposing the figure to be fixed; its collocation with respect to its two ends, the upper and the lower; the place; the position of the whole muscle; the introduction into it of nerves, arteries, veins. How are things including so many adjustments to be made? or, when made, how are they to be put together without intelligence?

I have sometimes wondered why we are not struck with mechanism in animal bodies as readily and as strongly as we are struck with it, at first sight, in a watch or a mill. One reason of the difference may be, that animal bodies are, in a great measure, made up of soft flabby substances, such as muscles and membranes; whereas we have been accustomed to trace mechanism in sharp lines, in the configuration of hard materials, in the moulding, chiseling, and filing into shapes of such articles as metals or wood. There is something therefore of habit in the case; but it is sufficiently evident that there can be no proper reason for any distinction of the sort. Mechanism may be displayed in the one kind of substance as well as in the other.

Although the few instances we have selected, even as they stand in our description, are nothing short, perhaps, of logical proofs of design, yet it must not be forgotten, that, in every part of anatomy, description is a poor substitute for inspection. It is well said by an able anatomist,* and said in reference to the very part

* Steno, in Blas. Anat. Animal, p. 2, c. 4.

of the subject which we have been treating of:—"Imperfecta hæc musculorum descriptio non minus arida est legentibus quam inspectantibus fuerit jucunda eorundem præparatio. Elegantissima enim mechanicês artificia, creber rimè in illis obvia, verbis nonnisi obscurè exprimuntur: carnium autem ductu, tendinum, colore, insertionum proportione, et trochlearium, distributione, oculis exposita, omnem superant admirationem."

CHAPTER X.

OF THE VESSELS OF ANIMAL BODIES.

The circulation of the *blood* through the bodies of men and quadrupeds, and the apparatus by which it is carried on, compose a system, and testify a contrivance, perhaps the best understood of any part of the animal frame. The lymphatic system, or the nervous system, may be more subtle and intricate—nay, it is possible that in their structure they may be even more artificial than the sanguiferous—but we do not know so much about them.

The utility of the circulation of the blood I assume as an acknowledged point. One grand purpose is plainly answered by it—the distributing to every part, every extremity, every nook and corner of the body, the nourishment which is recieved into it by one aperure. What enters at the mouth finds its way to the ingers' ends. A more difficult mechanical problem could hardly, I think, be proposed, than to discover a nethod of constantly repairing the waste, and of supplying an accession of substance to every part of a complicated machine at the same time.

This system presents itself under two views: first, he disposition of the blood-vessels, *i. e.* the laying of he pipes; and, secondly, the construction of the engine at the centre, viz. the heart, for driving the blood hrough them.

I. The disposition of the blood-vessels, as far as regards the supply of the body, is like that of the waterpipes in a city, viz. large and main trunks branching ff by smaller pipes (and these again by still narrower ubes) in every direction, and towards every part in which the fluid which they convey can be wanted. So far the water-pipes which serve a town may represent the vessels which carry the blood from the heart. But there is another thing necessary to the blood, which is not wanted for the water; and that is, the carrying of it back again to its source. For this office, reversed system of vessels is prepared, which, uniting at their extremities with the extremities of the first system, collects the divided and subdivided streamlets, by first, capillary ramifications into larger branches, secondly, by these branches into trunks; and thus returns the blood (almost exactly inverting the order in which it went out) to the fountain whence its motion proceeded. All which is evident mechanism.

The body, therefore, contains two systems of blood-vessels, arteries and veins. Between the constitutio of the systems there are also two differences, suited the functions which the systems have to execute. Th blood, in going out, passing always from wider in narrower tubes; and in coming back, from narrower in wider, it is evident that the impulse and pressure upo the sides of the blood-vessel will be much greater one case than the other. Accordingly, the arteri which carry out the blood are formed of much tough and stronger coats than the veins which bring it bac That is one difference: the other is still more artificia or, if I may so speak, indicates still more clearly th care and anxiety of the artificer. Forasmuch as, i the arteries, by reason of the greater force with whic the blood is urged along them, a wound or ruptu would be more dangerous than in the veins, these ve sels are defended from injury, not only by their textur but by their situation, and by every advantage of sit ation which can be given to them. They are burie sinuses, or they creep along grooves made for them i the bones; for instance, the under edge of the ribs sloped and furrowed solely for the passage of thes vessels. Sometimes they proceed in channels, protecte by stout parapets on each side, which last descriptio is remarkable in the bones of the fingers, these bein hollowed out, on the under side, like a scoop, and wit such a concavity that the finger may be cut acros to the bone without hurting the artery which run along it. At other times the arteries pass in canal wrought in the substance, and in the very middle o the substance, of the bone. This takes place in th lower jaw; and is found where there would, otherwise, be danger of compression by sudden curvature. All this care is wonderful, yet not more than what the importance of the case required. To those who venture their lives in a ship, it has been often said, that there is only an inch-board between them and death; but in the body itself, especially in the arterial system, there is, in many parts, only a membrane, a skin, a thread. For which reason, this system lies deep under integuments; whereas the veins, in which the mischief that ensues from injuring the coats is much less, lie in general above the arteries; come nearer to the surface; are more exposed.

It may be further observed concerning the two systems taken together, that though the arterial, with its trunk and branches and small twigs, may be imagined to issue or proceed—in other words, to *grow*, from the heart, like a plant from its root, or the fibres of a leaf from its foot-stalk, (which however, were it so, would be only to resolve one mechanism into another,) yet the venal, the returning system can never be formed in this manner. The arteries might go on shooting out from their extremities—*i. e.* lengthening and subdividing indefinitely; but an inverted system, continually uniting its streams, instead of dividing, and thus carrying back what the other system carries out, could not be referred to the same process.

II. The next thing to be considered is the engine which works this machinery—viz. the *heart*. For our purpose it is unnecessary to ascertain the principle upon which the heart acts. Whether it be irritation

excited by the contact of the blood, by the influx of th
nervous fluid, or whatever else be the cause of its mo
tion, it is something which is capable of producing, i
a living muscular fibre, reciprocal contraction and re
laxation. This is the power we have to work with
and the inquiry is, how this power is applied in the in
stance before us. There is provided, in the centra
part of the body, a hollow muscle, invested with spira
fibres, running in both directions, the layers intersect
ing one another; in some animals, however, appearin
to be semicircular rather than spiral. By the contrac
tion of these fibres the sides of the muscular cavitie
are necessarily squeezed together, so as to force ou
from them any fluid which they may at that time con
tain; by the relaxation of the same fibres, the cavitie
are in their turn dilated, and of course prepared to ad
mit every fluid which may be poured into them. Int
these cavities are inserted the great trunks, both of th
arteries which carry out the blood, and of the vein
which bring it back. This is a general account of th
apparatus; and the simplest idea of its action is, tha
by each contraction a portion of blood is forced by
syringe into the arteries; and, at each dilatation, a
equal portion is received from the veins. This pro
duces, at each pulse, a motion, and change in the mas
of blood, to the amount of what the cavity contain
which in a full-grown human heart I understand
about an ounce, or two table-spoons full. How quick
ly these changes succeed one another, and by this suc
cession how sufficient they are to support a stream o
circulation throughout the system, may be understoo

by the following computation, abridged from Keill's Anatomy, p. 117, ed. 3: "Each ventricle will at least contain one ounce of blood. The heart contracts four thousand times in one hour: from which it follows, that there pass through the heart, every hour, four thousand ounces, or three hundred and fifty pounds of blood. Now the whole mass of blood is said to be about twenty-five pounds: so that a quantity of blood, equal to the whole mass of blood passes through the heart fourteen times in one hour, which is about once in every four minutes."

Consider what an affair this is, when we come to very large animals. The aörta of a whale is larger in the bore than the main pipe of the water-works at London Bridge; and the water roaring in its passage through that pipe is inferior, in impetus and velocity, to the blood gushing from the whale's heart. Hear Dr. Hunter's account of the dissection of a whale: "The aörta measured a foot diameter. Ten or fifteen gallons of blood are thrown out of the heart at a stroke with an immense velocity, through a tube of a foot in diameter. The whole idea fills the mind with wonder."*

The account which we have here stated of the injection of blood into the arteries by the contraction, and of the corresponding reception of it from the veins by the dilatation, of the cavities of the heart, and of the circulation being thereby maintained through the blood-vessels of the body, is true, but imperfect. The heart

* Dr. Hunter's Account of the Dissection of a whale.—(Phil. Trans.)

performs this office, but it is in conjunction with an other of equal curiosity and importance. It was ne cessary that the blood should be successively brough into contact, or contiguity, or proximity with the *ai* I do not know that the chemical reason upon whic this necessity is founded, has been yet sufficiently ex plored. It seems to be made appear, that the atmos phere which we breathe is a mixture of two kinds o air: one pure and vital, the other, for the purposes o life, effete, foul, and noxious; that when we hav drawn in our breath the blood in the lungs imbibe from the air thus brought into contiguity with it a por tion of its pure ingredient, and at the same time give out the effete or corrupt air which it contained, an which is carried away, along with the halitus, ever time we expire. At least, by comparing the air whic is breathed from the lungs with the air which enter the lungs, it is found to have lost some of its pur part, and to have brought away with it an addition o its impure part. Whether these experiments satisf the question as to the need which the blood stands i of being visited by continual accesses of air, is not fo us to inquire into, nor material to our argument: it i sufficient to know, that in the constitution of most an mals such a necessity exists, and that the air, by som means or other, *must* be introduced into a near com munication with the blood. The lungs of animals ar constructed for this purpose. They consist of blood vessels and air-vessels, lying close to each other; an whenever there is a branch of the trachea or windpipe there is a branch accompanying it of the vein and ar tery, and the air-vessel is always in the middle between the blood-vessels.* The internal surface of these vessels upon which the application of the air to the blood depends, would, if collected and expanded, be, in a man, equal to a superficies of fifteen feet square. Now, in order to give the blood in its course the benefit of this organization, (and this is the part of the subject with which we are chiefly concerned,) the following operation takes place. As soon as the blood is received by the heart from the viens of the body, and *before* that is sent out again into its arteries, it is carried, by the force of the contraction of the heart, and by means of a separate and supplementary artery, to the lungs, and made to enter the vessels of the lungs, from which, after it has undergone the action, whatever it be, of that viscus, it is brought back by a large vein once more to the heart, in order, when thus concocted and prepared, to be thence distributed anew into the system. This assigns to the heart a double office. The pulmonary circulation is a system within a system; and one action of the heart is the origin of both.

For this complicated function four cavities become necessary, and four are accordingly provided; two called ventricles: which *send out* the blood, viz. one into the lungs, in the first instance; the other into the mass, after it has returned from the lungs: two others also, called auricles, which *receive* the blood from the veins, viz. one, as it comes immediately from the body; the other, as the same blood comes a second time after

* Keill's Anatomy, p. 121.

its circulation through the lungs. So that there are tw
receiving cavities, and two forcing cavities. The struc
ture of the heart has reference to the lungs; for with
out the lungs, one of each would have been sufficient
The translation of the blood in the heart itself is afte
this manner. The receiving cavities respectively com
municate with the forcing cavities, and, by their con
traction, unload the received blood into them. Th
forcing cavities, when it is their turn to contract, com
pel the same blood into the mouths of the arteries.

The account here given will not convey to a reade
ignorant of anatomy anything like an accurate notio
of the form, action, or use of the parts, (nor can an
short and popular account do this,) but it is abundant
ly sufficient to testify contrivance; and although im
perfect, being true as far as it goes, may be relied upo
for the only purpose for which we offer it—the pur
pose of this conclusion.

"The wisdom of the Creator," saith Hamburghe
"is in nothing seen more gloriously than in the heart."
And how well doth it execute its office! An anato
mist, who understood the structure of the heart, migh
say beforehand that it would play: but he would ex
pect, I think, from the complexity of its mechanism
and the delicacy of many of its parts, that it shoul
always be liable to derangement, or that it would soo
work itself out. Yet shall this wonderful machin
go, night and day, for eighty years together, at th
rate of a hundred thousand strokes every twenty-fou
hours, having, at every stroke, a great resistance t
overcome; and shall continue this action for thi

ngth of time without disorder and without weariness!
But further: from the account which has been given f the mechanism of the heart, it is evident that it must equire the interposition of *valves;* that the success ndeed of its action must depend upon these; for when ny one of its cavities contracts, the necessary tendeny of the force will be to drive the enclosed blood, not nly into the mouth of the artery where it ought to go, ut also back again into the mouth of the vein from hich it flowed. In like manner, when by the relaxaon of the fibres the same cavity is dilated, the blood ould not only run into it from the vein, which was ie course intended, but back from the artery, through hich it ought to be moving forward. The way of reventing a reflux of the fluid, in both these cases, is o fix valves, which, like flood-gates, may open a way o the stream in one direction, and shut up the passage gainst it in another. The heart, constituted as it is, an no more work without valves than a pump can. Vhen the piston descends in a pump, if it were not or the stoppage by the valve beneath, the motion ould only thrust down the water which it had before rawn up. A similar consequence would frustrate the ction of the heart. Valves, therefore, properly disposed, *e.* properly with respect to the course of the blood hich it is necessary to promote, are essential to the ontrivance. *And valves so disposed are accordingly rovided.* A valve is placed in the communication etween each auricle and its ventricle, lest, when the entricle contracts, part of the blood should get back gain into the auricle, instead of the whole entering

as it ought to do, the mouth of the artery. A valve is also fixed at the mouth of each of the great arteries which take the blood from the heart; leaving the passage free, so long as the blood holds its proper course forward; closing it, whenever the blood, in consequence of the relaxation of the ventricle, would attempt to flow back. There is some variety in the construction of these valves, though all the valves of the body act nearly upon the same principle, and are destined to the same use. In general they consist of a thin membrane, lying close to the side of the vessel, and consequently allowing an open passage while the stream runs one way, but thrust out from the side by the fluid getting behind it, and opposing the passage of the blood when it would flow the other way. Where more than one membrane is employed, the different membranes only compose one valve. Their joint action fulfils the office of a valve: for instance; over the entrance of the right auricle of the heart into the right ventricle, three of these skins or membranes are fixed, of a triangular figure, the basis of the triangles fastened to the flesh; the sides and summits loose; but, though loose, connected by threads of a determinate length, with certain small fleshy prominences adjoining. The effect of this construction is, that when the ventricle contracts, the blood endeavoring to escape in all directions, and amongst other directions pressing upwards, gets *between* these membranes and the sides of the passage; and thereby forces them up into such a position, as that together they constitute, when raised, a hollow cone, (the strings before spoken of hindering ıem from proceeding or separating further;) which ɔne, entirely occupying the passage, prevents the reᴜrn of the blood into the auricle. A shorter account ' the matter may be this: so long as the blood pro-ᴈeds in its proper course, the membranes which comɔse the valve are pressed close to the side of the ves-ᴈl, and occasion no impediment to the circulation: 'hen the blood would regurgitate, they are raised om the side of the vessel, and, meeting in the mid-.e of its cavity, shut up the channel. Can any one ɔubt of contrivance here; or is it possible to shut our ʋes against the proof of it?

This valve, also, is not more curious in its structure, ıan it is important in its office. Upon the play of the ılve, even upon the proportional length of the strings ' fibres which check the ascent of the membranes, ᴈpends, as it should seem, nothing less than the life self of the animal. We may here likewise repeat, hat we before observed concerning some of the liga-ıents of the body, that they could not be formed by ıy action of the parts themselves. There are cases which, although good uses appear to arise from the ıape or configuration of a part, yet that shape or con-guration itself may seem to be produced by the ac-ɔn of the part, or by the action or pressure of adjoining ırts. Thus the bend and the internal smooth conca-ty of the ribs may be attributed to the equal pressure ' the soft bowels; the particular shape of some bones nd joints, to the traction of the annexed muscles, or the position of contiguous muscles. But valves could ɔt be so formed. Action and pressure are all against them. The blood, in its proper course, has no tendency to produce such things: and in its improper or reflected current has a tendency to prevent their production. Whilst we see, therefore, the use and necessity of this machinery, we can look to no other account of its origin or formation than the intending mind of a Creator. Nor can we without admiration reflect, that such thin membranes, such weak and tender instruments as these valves are should be able to hold out for seventy or eighty years.

Here also we cannot consider but with gratitude how happy it is that our vital motions are *involuntary*. We should have enough to do, if we had to keep our hearts beating and our stomachs at work. Did these things depend, we will not say upon our effort, but upon our bidding, our care, or our intention, they would leave us leisure for nothing else. We must have been continually upon the watch, and continually in fear: nor would this constitution have allowed of sleep.

It might perhaps be expected, that an organ so precious, of such central and primary importance as the heart is, should be defended by a *case*. The fact is that a membranous purse or bag, made of strong, tough materials, is provided for it: holding the heart within its cavity: sitting loosely and easily about it; guarding its substance, without confining its motion; and containing likewise a spoonful or two of water, just sufficient to keep the surface of the heart in a state of suppleness and moisture. How should such a loose covering be generated by the action of the heart? Does not the enclosing of it in a sack, answering no other urpose but that enclosure, show the care that has been aken of its preservation.

One use of the circulation of the blood probably amongst other uses) is, to distribute nourishment to he different parts of the body. How minute and mul-iplied the ramifications of the blood-vessels for that urpose are; and how thickly spread over at least the uperficies of the body, is proved by the single obser-ation, that we cannot prick the point of a pin into the lesh without drawing blood, *i. e.* without finding a lood-vessel. Nor internally is their diffusion less uni-ersal. Blood-vessels run along the surface of mem-ranes, pervade the substance of muscles, penetrate he bones. Even into every tooth we trace, through a mall hole in the root, an artery to feed the bone, as vell as a vein to bring back the spare blood from it; oth which, with the addition of an accompanying ierve, form a thread only a little thicker than a iorse-hair.

Wherefore, when the nourishment taken in at the nouth has once reached and mixed itself with the lood, every part of the body is in the way of being upplied with it. And this introduces another grand opic, namely, the manner in which the aliment gets nto the *blood;* which is a subject distinct from the receeding, and brings us to the consideration of nother entire system of vessels.

III. For this necessary part of the animal economy n apparatus is provided in a great measure capable f being what anatomists call demonstrated, that is, hown in the dead body; and a line or course of conveyance, which we can pursue by our examination

First, the food descends by a wide passage into th intestines, undergoing two great preparations on it way: one in the mouth, by mastication and moistur —(can it be doubted with what design the teeth wer placed in the road to the stomach, or that there wa choice in fixing them in this situation?)—the other b digestion in the stomach itself. Of this last suprisin dissolution I say nothing; because it is chemistry, an I am endeavoring to display mechanism. The figur and position of the stomach (I speak all along with reference to the human organ) are calculated for de taining the food long enough for the action of its di gestive juice. It has the shape of the pouch of a bag pipe; lies across the body; and the pylorus, or passag by which the food leaves it, is somewhat higher in th body then the cardia or orifice by which it enters; s that it is by the contraction of the muscular coat of th stomach that the contents, after having undergone th application of the gastric menstruum, are graduall pressed out. In dogs and cats, this action of the coat of the stomach has been displayed to the eye. It is a slow and gentle undulation, propagated from one ori fice of the stomach to the other. For the same reason that I omitted, for the present, offering any observation upon the digestive fluid, I shall say nothing concern- ing the bile or the pancreatic juice, further than to ob serve upon the mechanism, viz. that from the glands in which these secretions are elaborated, pipes are laid into the first of the intestines, through which pipes the product of each gland flows into that bowel, and is there nixed with the aliment as soon almost as it passes the tomach; adding also as a remark, how grievously his same bile offends the stomach itself, yet cherishes he vessel that lies next to it.

Secondly. We have now the aliment in the intesines converted into a pulp; and though lately consistng of ten different viands, reduced to nearly a uniform ubstance, and to a state fitted for yielding its essence, vhich is called chyle, but which is milk, or more iearly resembling milk than any other liquor with vhich it can be compared. For the straining off this luid from the digestive aliment in the course of its ong progress through the body, myriads of capillary ubes, *i. e.* pipes as small as hairs, open their oriices into the cavity of every part of the intestines. These tubes, which are so fine and slender as not to e visible unless when distended with chyle, soon inite into larger branches. The pipes formed by this inion terminate in glands, from which other pipes, of still larger diameter, arising, carry the chyle from all oarts into a common reservoir or *receptacle*. This reeptacle is a bag of size enough to hold about two tale-spoons full; and from this vessel a duct or main pipe proceeds, climbing up the back part of the chest, and afterwards creeping along the gullet till it reach he neck. Here it meets the river; here it discharges tself into a large vein, which soon conveys the chyle, iow flowing along with the old blood, to the heart. This whole route can be exhibited to the eye; nothing s left to be supplied by imagination or conjecture. Now, besides the subserviency of this structure, collectively considered, to a manifest and necessary purpos we may remark two or three separate particulars in i which show, not only the contrivance, but the perfe tion of it. We may remark, first, the length of the i testines, which, in the human subject, is six times th of the body. Simply for a passage, these voluminou bowels, this prolixity of gut, seems in nowise necess ry; but in order to allow time and space for the su cessive extraction of the chyle from the digestive al ment, namely, that the chyle which escapes the la teals of one part of the guts may be taken up by thos of some other part, the length of the canal is of ev dent use and conduciveness. Secondly, we must als remark their peristaltic motion, which is made up c contractions following one another like waves upo the surface of a fluid, and not unlike what we observ in the body of an earthworm crawling along th ground, and which is effected by the joint action o longitudinal and of spiral, or rather perhaps of a gre number of separate semicircular fibres. This curiou action pushes forward the grosser part of the alimen at the same time that the more subtle parts, which w call chyle, are by a series of gentle compression squeezed into the narrow orifices of tne lacteal vein Thirdly, it was necessary that these tubes, which w denominate lacteals, or their mouths at least, shoul be made as narrow as possible, in order to deny ad mission into the blood to any particle which is of siz enough to make a lodgement afterwards in the sma arteries, and thereby to obstruct the circulation; an it was also necessary that this extreme tenuity shoul be compensated by multitude; for a large quantity of chyle (in ordinary constitutions not less, it has been computed, than two or three quarts in a day) is, by some means or other, to be passed through them. Accordingly, we find the number of the lacteals exceeding all powers of computation, and their pipes so fine and slender as not to be visible, unless filled, to the naked eye, and their orifices, which open into the intestines, so small as not to be discernible even by the best microscope. Fourthly, the main pipe, which carries the chyle from the reservoir to the blood, viz. the thoracic duct, being fixed in an almost upright position, and wanting that advantage of propulsion which the arteries possess, is furnished with a succession of valves to check the ascending fluid, when once it has passed them, from falling back. The valves look upwards, so as to leave the ascent free, but to prevent the return of the chyle, if, for want of sufficient force to push it on, its weight should at any time cause it to descend. Fifthly, the chyle enters the blood in an odd place, but perhaps the most commodious place possible, viz. at a large vein in the neck, so situated with respect to the circulation as speedily to bring the mixture to the heart. And this seems to be a circumstance of great moment; for had the chyle entered the blood at an artery, or at a distant vein, the fluid composed of the old and the new materials must have performed a considerable part of the circulation before it received that churning in the lungs which is probably necessary for the intimate and perfect union of the old blood with the recent chyle. Who could have dreamt of a communication between the cavity of the intestine and the left great vein of the *neck?* Who could hav suspected that this communication should be the me dium through which all nourishment is derived to th body, or this the place where, by a side inlet, the im portant junction is formed between the blood and th material which feeds it?

We postpone the consideration of *digestion*, lest should interrupt us in tracing the course of the food the blood; but in treating the alimentary system, s principal a part of the process cannot be omitted.

Of the gastric juice, the immediate agent by which th change which food undergoes in our stomachs is effec ed, we shall take our account from the numerous car ful, and varied experiments of the Abbé Spallanzan

1. It is not a simple diluent, but a real solvent. quarter of an ounce of beef had scarcely touched th stomach of a crow, when the solution began.

2. It has not the nature of saliva; it has not th nature of bile; but is distinct from both. By exp riments out of the body, it appears that neither of the secretions acts upon alimentary substances in the sam manner as the gastric juice acts.

3. Digestion is not *putrefaction;* for the digestin fluid resists putrefaction most pertinaciously; nay, n only checks its further progress, but restores putr substances.

4. It is not a *fermentative* process; for the solutio begins at the surface, and proceeds towards the centr contrary to the order in which fermentation acts an spreads.

5. It is not the *digestion of heat;* for the cold maw f a cod or sturgeon will dissolve the shells of crabs or obsters, harder than the sides of the stomach which ontains them.

In a word, animal digestion carries about it the narks of being a power and a process completely *sui eneris*, distinct from every other, at least from every hemical process with which we are acquainted. And he most wonderful thing about it is its appropriation —its subserviency to the particular economy of each nimal. The gastric juice of an owl, falcon, or kite vill not touch grain; no, not even to finish the macerated and half-digested pulse which is left in the crops f the sparrows that the bird devours. In poultry, the rituration of the gizzard, and the gastric juice, conspire n the work of digestion. The gastric juice will not lissolve the grain whilst it is whole. Entire grains of arley, enclosed in tubes or spherules, are not affected y it. But if the same grain be by any means broken r ground, the gastric juice immediately lays hold of it. Iere then is wanted, and here we find, a combination f mechanism and chemistry. For the preparatory rinding, the gizzard lends its mill; and as all millvork should be strong, its structure is so beyond that f any other muscle belonging to the animal. The nternal coat also, or lining of the gizzard, is, for the ame purpose, hard and cartilaginous. But, forasnuch as this is not the sort of animal substance uited for the reception of glands, or for secretion, the astric juice, in this family, is not supplied, as in nembranous stomachs, by the stomach itself, but by the gullet, in which the feeding-glands are placed and from which it trickles down into the stomach

In sheep, the gastric fluid has no effect in digesting plants, *unless they have been previously masticated* It only produces a slight maceration, nearly such a common water would produce, in a degree of hea somewhat exceeding the medium temperature of th atmosphere. But, provided that the plant has been re duced to pieces by chewing, the gastric juice then pro ceeds with it, first, by softening its substance; nex by destroying its natural consistency; and, lastly, b dissolving it so completely as not even to spare th toughest and most stringy parts, such as the nerves o the leaves.

So far our accurate and indefatigable Abbé, D Stevens, of Edinburgh, in 1777, found, by experimen tried with perforated balls, that the gastric juice of th sheep and the ox speedily dissolved vegetables, but mad no impression upon beef, mutton and other animal bo dies. Mr. Hunter discovered a property of this flui of a most curious kind—viz. that in the stomachs o animals which feed upon flesh, irresistibly as this flui acts upon animal substances, it is only upon the *dea* substance that it operates at all. The *living* fibr suffers no injury from lying in contact with it. Worm and insects are found alive in the stomachs of suc animals. The coats of the human stomach, in a hea thy state, are insensible to its presence; yet in case of sudden death, (wherein the gastric juice, not havin been weakened by disease, retains its activity,) it ha been known to eat a hole through the bowel whic contains it.* How nice is this discrimination of action, yet how necessary!

But to return to our hydraulics.

IV. The gall-bladder is a very remarkable contrivance. It is the reservoir of a canal. It does not form the canal itself—*i. e.* the direct communication between the liver and the intestine, which is by another passage—viz. the ductus hepaticus, continued under the name of the ductus communis; but it lies adjacent to this channel, joining it by a duct of its own, the ductus cysticus: by which structure it is enabled, as occasion may require, to add its contents to and increase the flow of bile into the duodenum. And the position of the gall-bladder is such as to apply this structure to the best advantage. In its natural situation, it touches the exterior surface of the stomach, and consequently is compressed by the distention of that vessel: the effect of which compression is to force out from the bag, and send into the duodenum, an extraordinary quantity of bile, to meet the extraordinary demand which the repletion of the stomach by food is about to occasion.† Cheselden describes ‡ the gall-bladder as seated against the duodenum, and thereby liable to have its fluid pressed out by the passage of the aliment through that cavity, which likewise will have the effect of causing it to be received into the intestine at a right time and in a due proportion.

There may be other purposes answered by this con-

* Phil. Trans. vol. lxii. p. 447.

† Keill's Anat. p. 64.

‡ Anat. p. 164.

trivance, and it is probable that there are. The contents of the gall-bladder are not exactly of the same kind as what passed from the liver through the direct passage.* It is possible that the gall may be changed, and for some purposes meliorated, by keeping.

The entrance of the gall-duct into the duodenum furnishes another observation. Whenever either smaller tubes are inserted into larger tubes, or tubes into vessels and cavities, such receiving tubes, vessels, or cavities, being subject to muscular constriction, we always find a contrivance to prevent *regurgitation.* In some cases valves are used; in other cases, amongst which is that now before us, a different expedient is resorted to, which may be thus described; the gall-duct enters the duodenum obliquely; after it has pierced the first coat it runs near two finger's breadth *between* the coats before it opens into the cavity of the intestine.† The same contrivance is used in another part, where there is exactly the same occasion for it, viz. in the insertion of the ureters in the bladder. These enter the bladder near its neck, running obliquely for the space of an inch between its coats.‡ It is, in both cases, sufficiently evident that this structure has a necessary mechanical tendency to resist regurgitation; for whatever force acts in such a direction as to urge the fluid back into the orifices of the tubes, must, at the same time, stretch the coats of the vessels, and thereby compress that part of the tube which is included between them.

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* Keill, (from Malpighius,) p. 63. † Keill's Anat. p. 62.
‡ Ches. Anat. p. 260.

V. Amongst the *vessels* of the human body, the pipe vhich conveys the saliva from the place where it is nade to the place where it is wanted, deserves to be eckoned amongst the most intelligible pieces of me-hanism with which we are acquainted. The saliva, ve all know, is used in the mouth; but much of it is roduced on the outside of the cheek by the parotid land, which lies between the ear and the angle of the ower jaw. In order to carry the secreted juice to its lestination, there is laid from the gland on the outside pipe about the thickness of a wheat straw, and about hree fingers' breadth in length, which, after riding ver the masseter muscle, bores for itself a hole through he very middle of the cheek, enters by that hole, vhich is a complete perforation of the buccinator mus-le, into the mouth, and there discharges its fluid very opiously.

VI. Another exquisite structure, differing, indeed, rom the four preceding instances, in that it does not elate to the conveyance of fluids, but still belonging, ike these, to the class of pipes or conduits of the body, s seen in the *larynx*. We all know that there go lown the throat two pipes, one leading to the stomach, he other to the lungs—the one being the passage for he food, the other for the breath and voice: we know lso, that both these passages open into the bottom of he mouth—the gullet, necessarily, for the conveyance f food, and the windpipe, for speech and the modula-ion of sound, not much less so: therefore the difficulty vas, the passages being so contiguous, to prevent the ood, especially the liquids, which we swallow into the stomach, from entering the windpipe, *i. e.* the road to the lungs—the consequence of which error, when it does happen, is perceived by the convulsive throes that are instantly produced. This business, which is very nice, is managed in this manner. The gullet (the passage for food) opens into the mouth like the cone or upper part of a funnel, the capacity of which forms indeed the bottom of the mouth. Into the side of this funnel, at the part which lies the lowest, enters the windpipe by a chink or slit, with a lid or flap, like a little tongue, accurately fitted to the orifice. The solids or liquids which we swallow pass over this lid or flap as they descend by the funnel into the gullet. Both the weight of the food and the action of the muscles concerned in swallowing contribute to keep the lid close down upon the aperture whilst any thing is passing; whereas, by means of its natural cartilaginous spring, it raises itself a little as soon as the food is passed, thereby allowing a free inlet and outlet for the respiration of air by the lungs. Such is its structure; and we may here remark the almost complete success of the expedient, viz. how seldom it fails of its purpose compared with the number of instances in which it fulfils it. Reflect how frequently we swallow, how constantly we breathe. In a city feast, for example, what deglutition, what anhelation! yet does this little cartilage, the epiglottis, so effectually interpose its office, so securely guard the entrance of the windpipe, that whilst morsel after morsel, draught after draught, are coursing one another over it, an accident of a crumb or a drop slipping into this passage, (which nevertheless, must be opened for the breath every second of time,) excites in the whole company not only alarm by its danger, but surprise by its novelty. Not two guests are choked in a century.

There is no room for pretending that the action of the parts may have gradually formed the epiglottis: I do not mean in the same individual, but in a succession of generations. Not only the action of the parts has no such tendency, but the animal could not live, nor consequently the parts act, either without it or with it in a half-formed state. The species was not to wait for the gradual formation or expansion of a part which was from the first necessary to the life of the individual.

Not only is the larynx curious, but the whole windpipe possesses a structure adapted to its peculiar office. It is made up (as any one may perceive by putting his fingers to his throat) of stout cartilaginous ringlets, placed at small and equal distances from one another. Now this is not the case with any other of the numerous conduits of the body. The use of these cartilages is to keep the passage for the air *constantly* open, which they do mechanically. A pipe with soft membranous coats, liable to collapse and close when empty, would not have answered here; although this be the general vascular structure, and a structure which serves very well for those tubes which are kept in a state of perpetual distention by the fluid they enclose, or which afford a passage to solid and protruding substances.

Nevertheless, (which is another particularity well worthy of notice,) these rings are not complete—that is, are not cartilaginous and stiff all round; but their hinder part, which is contiguous to the gullet, is membranous and soft, easily yielding to the distensions of that organ occasioned by the descent of solid food. The same rings are also bevelled off at the upper and lower edges, the better to close upon one another when the trachea is compressed or shortened.

The constitution of the trachea may suggest likewise another reflection. The membrane which lines its inside is perhaps the most sensible, irritable membrane of the body. It rejects the touch of a crumb of bread, or a drop of water, with a spasm which convulses the whole frame; yet, left to itself and its proper office, the intromission of air alone, nothing can be so quiet. It does not even make itself felt; a man does not know that he has a trachea. This capacity of perceiving with such acuteness, this impatience of offence, yet perfect rest and ease when left alone, are properties, one would have thought, not likely to reside in the same subject. It is to the junction, however, of these almost inconsistent qualities, in this, as well as in some other delicate parts of the body, that we owe our safety and our comfort—our safety to their sensibility, our comfort to their repose.

The larynx, or rather the whole windpipe taken together, (for the larynx is only the upper part of the windpipe,) besides its other uses, is also a musical instrument—that is to say, it is *mechanism* expressly adapted to the modulation of sound; for it has been found upon trial, that by relaxing or tightening the tendinous bands at the extremity of the wind-pipe, and blowing in at the other end, all the cries and notes might be produced of which the living animal was capable. It can be sounded just as a pipe or flute is sounded.

Birds, says Bonnet, have at the lower end of the windpipe a conformation like the reed of a hautboy, for the modulation of their notes. A tuneful bird is a ventriloquist. The seat of the song is in the breast.

The use of the lungs *in* the system has been said to be obscure; one use, however, is plain, though, in some sense, external to the system, and that is, the formation, in conjunction with the larynx, of voice and speech. They are, to animal utterance, what the bellows are to the organ.

For the sake of method, we have considered animal bodies under three divisions; their bones, their muscles, and their vessels; and we have stated our observations upon these parts separately. But this is to diminish the strength of the argument. The wisdom of the Creator is seen, not in their separate but their collective action; in their mutual subserviency and dependence: in their contributing *together* to one effect and one use. It has been said, that a man cannot lift his hand to his head without finding enough to convince him of the existence of a God. And it is well said; for he has only to reflect, familiar as this action is, and simple as it seems to be, how many things ar requisite for the performing of it; how many thing which we understand, to say nothing of many mor probably which we do not: viz. first, a long, har strong cylinder, in order to give to the arm its firmnes and tension; but which, being rigid, and in its sub stance, inflexible, can only turn upon joints; secondly therefore, joints for this purpose; one at the shoulde to raise the arm, another to the elbow to bend it; thes joints continually fed with a soft mucilage to mak the parts slip easily upon one another, and holden to gether by strong braces, to keep them in their position then, thirdly, strings and wires—*i. e.* muscles and ten dons—artificially inserted, for the purpose of drawin the bones in the directions in which the joints allov them to move. Hitherto we seem to understand th mechanism pretty well; and, understanding this, w possess enough for our conclusion: Nevertheless, w have hitherto only a machine standing still—a dea organization—an apparatus. To put the system i a state of activity, to set it at work, a further prov sion is necessary—viz. a communication with th brain by means of nerves. We know the existence this communication, because we can see the commu nicating threads, and can trace them to the brain: it necessity we also know, because if the thread be cu if the communication be intercepted, the muscle be comes paralytic; but beyond this we know littl the organization being too minute and subtile for ou inspection.

To what has been enumerated, as officiating i he single act of a man's raising his hand to his head, ıust be added likewise all that is necessary and all ıat contributes to the growth, nourishment, and sus-entation of the limb, the repair of its waste, the preser-ation of its health; such as the circulation of the blood ırough every part of its lymphatics, exhalents, absor-ents; its excretions and integuments. All these share ı the result—join in the effect; and how all these, or ny of them, come together without a designing, dis-osing intelligence, it is impossible to conceive.

CHAPTER XI.

F THE ANIMAL STRUCTURE REGARDED AS A MASS.

Contemplating *an animal body* in its collective capa-ity, we cannot forget to notice what a number of in-truments are brought together, and often within how mall a compass. It is a cluster of contrivances, in a anary-bird, for instance, and in the single ounce of natter which composes his body, (but which seems o be all employed,) we have instruments for eating, or digesting, for nourishment, for breathing, for gene-ation, for running, for flying, for seeing, for hearing, or smelling: each appropriate—each entirely different rom all the rest.

The human or indeed the animal frame considered as a mass or assemblage, exhibits in its compositi three properties which have long struck my mind indubitable evidences not only of design, but of great deal of attention and accuracy in prosecuti the design.

I. The first is, the exact correspondency of the tw sides of the same animal; the right hand answerin to the left, leg to leg, eye to eye, one side of the cou tenance to the other; and with a precision, to imita which in any tolerable degree forms one of the dif culties of statuary, and requires, on the part of th artist, a constant attention to this property of his wo distinct from every other.

It is the most difficult thing that can be to get a w made even; yet how seldom is the *face* awry! An what care is taken that it should not be so, the anatom of its bones demonstrates. The upper part of the fac is composed of thirteen bones, six on each side, answe ing each to each, and the thirteenth, without a fellov in the middle. The lower part of the face is in lik manner composed of six bones, three on each side, r spectively corresponding, and the lower jaw in th centre. In building an arch, could more be done i order to make the curve *true*—*i. e.* the parts equidi tant from the middle, alike in figure and position

The exact resemblance of the *eyes*, considering ho compounded this organ is in its structure, how v rious and how delicate are the shades of color wi which its iris is tinged; how differently, as to effe upon appearance, the eye may be mounted in its sock and how differently in different heads eyes actual are set—is a property of animal bodies much to be admired. Of ten thousand eyes, I do not know that it would be possible to match one, except with its own fellow; or to distribute them into suitable pairs by any other selection than that which obtains.

This regularity of the animal structure is rendered more remarkable by the three following considerations:

1. The limbs, *separately* taken, have not this correlation of parts, but the contrary of it. A knife drawn down the chine cuts the human body into two parts, externally equal and alike; you cannot draw a straight line which will divide a hand, a foot, the leg, the thigh, the cheek, the eye, the ear, into two parts equal and alike. Those parts which are placed upon the middle or partition line of the body, or which traverse that line—as the nose, the tongue, and the lips—may be so divided, or more properly speaking, are double organs; but other parts cannot. This shows that the correspondency which we have been describing does not arise by any necessity in the nature of the subject; for, if necessary, it would be universal; whereas it is observed only in the system or assemblage. It is not true of the separate parts: that is to say, it is not found where it conduces to beauty or utility; it is found where it would subsist at the expense of both. The two wings of a bird always correspond: the two sides of a feather frequently do not. In centipedes, millepedes, and the whole tribe of insects, no two legs on the same side are alike; yet there is the most exact parity between the legs opposite to one another.

2. The next circumstance to be remaked is, that

whilst the cavities of the body are so configurated, as *externally* to exhibit the most exact correspondency of the opposite sides, the contents of these cavities have no such correspondency. A line drawn down the middle of the breast divides the thorax into two sides exactly similar; yet these two sides enclose very different contents. The heart lies on the left side; a lobe of the lungs on the right; balancing each other neither in size nor shape. The same thing holds of the abdomen. The liver lies on the right side, without any similar viscus opposed to it on the left. The spleen indeed is situated over against the liver: but agreeing with the liver neither in bulk nor form. There is no equipollency between these. The stomach is a vessel, both irregular in its shape, and oblique in its position. The foldings and doublings of the intestines do not present a parity of sides. Yet that symmetry which depends upon the correlation of the sides is externally preserved throughout the whole trunk; and is the more remarkable in the lower parts of it, as the integuments are soft; and the shape, consequently, is not, as the thorax is by its ribs, reduced by natural stays. It is evident, therefore, that the external proportion does not arise from any equality in the shape or pressure of the internal contents. What is it, indeed but a correction of inequalities?—an adjustment, by mutual compensation, of anomalous forms into a regular congeries?—the effect, in a word, of artful, and if we might be permitted to speak, of studied collocation?

3. Similar also to this is the third observation: that

ın internal inequality in the feeding vessel is so man-
ıged as to produce no inequality of parts which were
ntended to correspond. The right arm answers accu-
ately to the left, both in size and shape; but the ar-
erial branches which supply the two arms do not go
off from their trunk, in a pair, in the same manner,
ıt the same place, or at the same angle. Under
which want of similitude, it is very difficult to con-
eive how the same quantity of blood should be push-
d through each artery; yet the result is right; the two
imbs which are nourished by them perceive no dif-
erence of supply—no effects of excess or deficiency.

Concerning the difference of manner in which the
ubclavian and carotid arteries, upon the different sides
of the body, separate themselves from the aörta, Che-
elden seems to have thought, that the advantage
which the left gain by going off at an angle much
more acute than the right, is made up to the right by
heir going off together in one branch.* It is very pos-
ible that this may be the compensating contrivance;
ınd if it be so, how curious—how hydrostatical!

II. Another perfection of the animal mass is the
package. I know nothing which is so surprising.
Examine the contents of the trunk of any large ani-
nal. Take notice how soft, how tender, how intricate
hey are; how constantly in action, how necessary to
ife! Reflect upon the danger of any injury to their
ubstance, any derangement to their position, any ob-
truction to their office. Observe the heart pumping

* Ches. Anat. p. 184, ed. 7.

at the centre, at the rate of eighty strokes in a minute; one set of pipes carrying the stream away from it, another set bringing, in its course, the fluid back to it again; the lungs performing their elaborate office, viz. distending and contracting their many thousand vesicles by a reciprocation which cannot cease for a minute; the stomach exercising its powerful chemistry; the bowels silently propelling the changed aliment; collecting from it, as it proceeds, and transmitting to the blood an incessant supply of prepared and assimilated nourishment; that blood pursuing its course; the liver, the kidneys, the pancreas, the parotid, with many other known and distinguishable glands, drawing off from it, all the while, their proper secretions. These several occupations, together with others more subtile but less capable of being investigated, are going on within us at one and the same time. Think of this; and then observe how the body itself, the case which holds this machinery, is rolled, and jolted, and tossed about, the mechanism remaining unhurt, and with very little molestation even of its nicest motions. Observe a rope-dancer, a tumbler, or a monkey; the sudden inversions and contortions which the internal parts sustain by the postures into which their bodies are thrown; or rather observe the shocks which these parts, even in ordinary subjects, sometimes receive from falls and bruises, or by abrupt jerks and twists, without sensible or with soon-recovered damage. Observe this, and then reflect how firmly every part must be secured, how carefully surrounded, how well tied down and packed together.

This property of animal bodies has never, I think, ȝen considered under a distinct head, or so fully as it ȝserves. I may be allowed therefore, in order to vefy my observation concerning it, to set forth a short ıatomical detail, though it oblige me to use more chnical language than I should wish to introduce .to a work of this kind.

1. The *heart* (such care is taken of the centre of :e) is placed between two soft lobes of the lungs; is *.ed* to the mediastinum and to the pericardium; which ·ricardium is not only itself an exceedingly strong :embrane, but *adheres* firmly to the duplicature of ıe mediastinum, and, by its point, to the middle tenon of the diaphragm. The heart is also *sustained* : its place by the gerat blood-vessels which issue :om it.*

2. The *lungs* are *tied* to the sternum by the medistinum before; to the vertebræ by the pleura behind. seems indeed to be the very use of the mediastinum which is a membrane that goes straight through the iddle of the thorax, from the breast to the back) to ep the contents of the thorax in their places; in partular to hinder one lobe of the lungs from incomoding another, or the parts of the lungs from pressg upon each other when we lie on one side.†

3. The *liver* is fastened in the body by two ligaents: the first, which is large and strong, comes om the covering of the diaphragm, and penetrates e substance of the liver; the second is the umbilical

Keill's Anat. p. 107, ed. 3.

† Ib. p. 119, ed. 3.

vein, which, after birth, degenerates into a ligame
The first, which is the principal, fixes the liver in
situation whilst the body holds an erect posture; t
second prevents it from pressing upon the diaphrag
when we lie down; and both together *sling* or su
pend the liver when we lie upon our backs, so that
may not compress or obstruct the ascending ve
cava,* to which belongs the important office of retu
ing the blood from the body to the heart.

4. The *bladder* is tied to the naval by the urach
transformed into a ligament: thus, what was a p
sage for urine to the fœtus, becomes, after birth,
support or stay to the bladder. The peritonæum a
keeps the viscera from confounding themselves wi
or pressing irregularly upon the bladder; for the k
neys and bladder are contained in a distinct dupli
ture of that membrane, being thereby partitioned
from the other contents of the abdomen.

5. The *kidneys* are lodged in a bed of fat.

6. The *pancreas*, or sweetbread, is strongly tied
the peritonæum, which is the great wrapping sheet t
encloses all the bowels contained in the lower bell

7. The *spleen* also is confined to its place by
adhesion to the peritonæum and diaphragm, and by
connection with the omentum.‡ It is possible, in r
opinion, that the spleen may be merely a *stuffing*
soft cushion to fill up a vacancy or hollow, whi
unless occupied, would leave the package loose a
unsteady: for, supposing that it answers no other p

* Ches. Anat. p. 162. † Keill's Anat. p. 57. ‡ Ches. Anat. p. 16

ose than this, it must be vascular, and admit of a rculation through it, in order to be kept alive, or be part of a living body.

8. The *omentum*, epiplöon, or cawl, is an apron cked up, or doubling upon itself, at its lowest part. he upper edge is tied to the bottom of the stomach, the spleen, as hath already been observed, and to rt of the duodenum. The reflected edge also, after rming the doubling, comes up behind the front flap, d is tied to the colon and adjoining viscera.*

9. The septa of the brain probably prevent one part the organ from pressing with too great a weight on another part. The processes of the dura mater vide the cavity of the skull, like so many inner parion walls, and thereby confine each hemisphere and be of the brain to the chamber which is assigned to without its being liable to rest upon or intermix ith the neighboring parts. The great art and caution packing is to prevent one thing hurting another. his, in the head, the chest, and the abdomen of an imal body is, amongst other methods, provided for membranous partitions and wrappings, which keep e parts separate.

The above may serve as a short account of the anner in which the principal viscera are sustained their places. But of the provisions for this purpose, far, in my opinion, the most curious, and where so such a provision was most wanted, is in the *guts*. is pretty evident that a long narrow tube (in man,

* Ches. Anat. p. 167.

about five times the length of the body,) laid from sid to side in folds upon one another, winding in obliqu and circuitous directions, composed also of a soft an yielding substance, must, without much extraordinar precaution for its safety, be continually displaced b the various, sudden, and abrupt motions of the bod which contains it. I should expect that, if not bruise or wounded by every fall, or leap, or twist, it woul be entangled, or be involved with itself; or, at th least slipped, and shaken out of the order in which i is disposed, and which order is necessary to be pre served for the carrying on of the important function which it has to execute in the animal economy. Le us see, therefore, how a danger so serious, and yet s natural to the length, narrowness and tubular form o the part, is provided against. The expedient is admi rable, and it is this. The intestinal canal, throughou its whole process, is knit to the edge of a broad fa membrane called the mesentery. It forms the margi of this mesentery, being stitched and fastened to i like the edging of a ruffle; being four times as lon as the mesentery itself, it is what a seamstress woul call "puckered or gathered on" to it. This is the na ture of the connection of the gut with the mesentery and being thus joined to, or rather made a part of, th mesentery, it is folded and wrapped up together wit it. Now the mesentery, having a considerable dimen sion in breadth, being in its substance withal both thic and suety, is capable of a close and safe folding, in comparison of what the intestinal tube would admi of if it had remained loose. The mesentery likewis ot only keeps the intestinal canal in its proper place nd position under all the turns and windings of its ourse, but sustains the numberless small vessels, the rteries, the veins, the lympheducts, and above all, the acteals, which lead from or to almost every point of s coats and cavity. This membrane, which appears o be the great support and security of the alimentary pparatus, is itself strongly tied to the first three ver- ebræ of the loins.*

III. A third general property of animal forms is *eauty*. I do not mean relative beauty, or that of one ndividual above another of the same species; but I nean, generally, the provision which is made in the ody of almost every animal to adapt its appearance o the perception of the animals with which it con- erses. In our own species, for example, only consi- er what the parts and materials are of which the fair- st body is composed; and no further observation will e necessary to show how well these things are wrap- ed up, so as to form a mass which shall be capable f symmetry in its proportion, and of beauty in its as- ect; how the bones are covered, the bowels conceal- d, the roughnesses of the muscle smoothed and soft- ned; and how over the whole is drawn an integu- nent which converts the disgusting materials of a issecting-room into an object of attraction to the sight, r one upon which it rests at least with ease and sa- isfaction. Much of this effect is to be attributed to he intervention of the cellular or adipose membrane,

* Keill's Anat. p. 45.

which lies immediately under the skin; is a kind o lining to it; is moist, soft, slippery, and compressible everywhere filling up the insterstices of the muscle and forming thereby their roundness and flowing lin as well as the evenness and polish of the whole surfac

All which seems to be a strong indication of desig and of a design studiously directed to this purpos And it being once allowed that such a purpose existe with respect to *any* of the productions of nature, we ma refer with a considerable degree of probability, oth particulars to the same intention; such as the tints o flowers, the plumage of birds, the furs of beasts, th bright scales of fishes, the painted wings of butterfli and beetles, the rich colors and spotted lustre of man tribes of insects.

There are parts also of animals ornamental, an the properties by which they are so not subservien that we know of, to any other purpose. The *irides* o most animals are very beautiful, without conducin at all, by their beauty, to the perfection of vision; an nature could in no part have employed her pencil t so much advantage, because no part presents itself s conspicuously to the observer, or communicates s great an effect to the whole aspect.

In plants, especially in the flowers of plants, th principle of beauty holds a still more considerab place in their composition; is still more confessed tha in animals. Why, for one instance out of a thousan does the corolla of the tulip, when advanced to its siz and maturity, change its color? The purposes, so fa as we can see, of vegetable nutrition might have bee arried on as well by its continuing green. Or, if this ould not be, consistently with the progress of vegeta-le life, why break into such a variety of colors? This no proper effect of age, or of declension in the ascent the sap; for that, like the autumnal tints, would ave produced one color on one leaf, with marks of ding and withering. It seems a lame account to ll it, as it has been called, a disease of the plant. it not more probable that this property, which is in-ependent, as it should seem, of the wants and utili-es of the plant, was calculated for beauty, intended r display?

A ground, I know, of objection has been taken gainst the whole topic of argument, namely, that ere is no such thing as beauty at all; in other ords, that whatever is useful and familiar comes of ourse to be thought beautiful; and that things ap-ear to be so, only by their alliance with these quali-es. Our idea of beauty is capable of being in so reat a degree modified by habit, by fashion, by the xperience of advantage or pleasure, and by associa-ons arising out of that experience, that a question has een made whether it be not altogether generated by ese causes, or would have any proper existence ithout them. It seems, however, a carrying of the onclusion too far, to deny the existence of the princi-le, viz. a native capacity of perceiving beauty, on ac-ount of an influence, or of varieties proceeding from at influence, to which it is subject, seeing that princi-les the most acknowledged are liable to be affected the same manner. I should rather argue thus:—

The question respects objects of sight. Now eve other sense hath its distinction of agreeable and dis greeable. Some tastes offend the palate, others grati it. In brutes and insects, this distinction is strong and more regular than in man. Every horse, c sheep, swine, when at liberty to choose, and when in natural state; that is, when not vitiated by hab forced upon it, eats and rejects the same plants. Ma insects which feed upon particular plants, will rath die than change their appropriate leaf. All this loo like a determination in the sense itself to particul tastes. In like manner, smells affect the nose with se sations pleasurable or disgusting. Some sounds, compositions of sound, delight the ear: others tortu it. Habit can do much in all these cases, (and it well for us that it can; for it is this power which r conciles us to many necessities,) but has the distin tion, in the mean time, of agreeable and disagreeal no foundation in the sense itself? What is true of t other senses is most probably true of the eye, (the an logy is irresistible,) viz. that there belongs to it original constitution, fitted to receive pleasure fro some impressions, and pain from others.

I do not however know that the argument whi alleges beauty as a final cause rests upon this conc sion. We possess a sense of beauty, however we co by it. It in fact exists. Things are not indifferent this sense; all objects do not suit it; many, which see, are agreeable to it: many others disagreeable. is certainly not the effect of habit upon the particul object, because the most agreeable objects are often t ıost rare; many which are very common, continue) be offensive. If they be made supportable by habit, is all which habit can do; they never become agreeale. If this sense, therefore, be acquired, it is a result; ıe produce of numerous and complicated actions of xternal objects upon the senses, and of the mind upon s sensations. With this *result*, there must be a cerin congruity to enable any particular object to please; ıd that congruity, we contend, is consulted in the *spect* which is given to animal and vegetable bodies.

IV. The skin and covering of animals is that upon hich their appearance chiefly depends; and it is that ırt which, perhaps, in all animals, is most decorated, ıd most free from impurities. But were beauty, or greeableness of aspect, entirely out of the question, ere is another purpose answered by this integument, ıd by the collocation of the parts of the body beneath which is of still greater importance; and that purse is *concealment*. Were it possible to view through e skin the mechanism of our bodies, the sight would ghten us out of our wits. "Durst we make a single ovement," asks a lively French writer, "or stir a ep from the place we were in, if we *saw* our blood rculating, the tendons pulling, the lungs blowing, e humors filtrating, and all the incomprehensible semblage of fibres, tubes, pumps, valves, currents, vots, which sustain an existence at once so frail and presumptuous?"

V. Of animal bodies, considered as masses, there is other property, more curious than it is generally ought to be; which is the faculty of *standing:* and it is more remarkable in two-legged animals than quadrupeds, and, most of all, as being the tallest, ar resting upon the smallest base, in man. There is mor I think, in the matter than we are aware of. The st tue of a man placed loosely upon a pedestal, would n be secure of standing half an hour. You are oblig to fix its feet to the block by bolts and solder; or tl first shake, the first gust of wind, is sure to throw down. Yet this statue shall express all the mechar cal proportions of a living model. It is not therefo the mere figure, or merely placing the centre of gravi within the base, that is sufficient. Either the law gravitation is suspended in favor of living substance or something more is done for them, in order to enab them to uphold their posture. There is no reaso whatever to doubt, but that their parts descend l gravitation in the same manner as those of dead ma ter. The gift therefore appears to me to consist in faculty of perpetually shifting the centre of gravity, l a set of obscure, indeed, but of quick-balancing a tions, so as to keep the line of direction, which is line drawn from the centre to the ground, within i prescribed limits.

Of these actions it may be observed, first, that th in part constitute what we call strength. The de body drops down. The mere adjustment therefore weight and pressure, which may be the same the m ment after death as the moment before, does not su port the column. In cases also of extreme weaknes the patient cannot stand upright. Secondly, that the actions are only in a small degree voluntary. A ma s seldom conscious of his voluntary powers in keeping himself upon his legs. A child learning to walk s the greatest posture-master in the world: but art, if t may be so called, sinks into habit; and he is soon ble to poise himself in a great variety of attitudes, without being sensible either of caution or effort. But till there must be an aptitude of parts, upon which abit can thus attach; a previous capacity of motions which the animal is thus taught to exercise, and the acility with which this exercise is acquired, forms one bject of our admiration. What parts are principally mployed, or in what manner each contributes to its ffice, is, as hath already been confessed, difficult to xplain. Perhaps the obscure motion of the bones of he feet may have their share in this effect. They are ut in action by every slip or vacillation of the body, nd seem to assist in restoring its balance. Certain it s, that this circumstance in the structure of the foot, iz. its being composed of many small bones, applied o and articulating with one another by diversely haped surfaces, instead of being made of one piece, ke the last of a shoe, is very remarkable.

I suppose also that it would be difficult to stand rmly upon stilts or wooden legs, though their base xactly imitated the figure and dimensions of the sole f the foot. The alternation of the joints, the kneeoint bending backward, the hip-joint forward; the exibility, in every direction, of the spine, especially n the loins and neck, appear to be of great moment n preserving the equilibrium of the body. With respect to this last circumstance, it is observable that the vertebræ are so confined by ligaments as to allow n more slipping upon their bases than what is just suff cient to break the shock which any violent motio may occasion to the body. A certain degree also c tension of the sinews appears to be essential to a erect posture; for it is by the loss of this that the dea or paralytic body drops down.

The whole is a wonderful result of combined pow ers and of very complicated operations. Indeed, tha *standing* is not so simple a business as we imagine i to be, is evident from the strange gesticulations of a drunken man, who has lost the government of th centre of gravity.

We have said that this property is the most worth of observation in the *human* body; but a *bird*, restin upon its perch, or hopping upon a spray, affords n mean specimen of the same faculty. A chicken run off as soon as it is hatched from the egg; yet a chick en, considered geometrically, and with relation to it centre of gravity, its line of direction, and its equili brium, is a very irregular solid. Is this gift, therefore or instruction? May it not be said to be with grea attention that nature hath balanced the body upon its pivots?

I observe also in the same *bird* a piece of usefu mechanism of this kind. In the trussing of a fowl, upon bending the legs and thighs up towards the body the cook finds that the claws close of their own accord. Now let it be remembered, that this is the position o the limbs in which the bird rests upon its perch. And in this position it sleeps in safety; for the claws do heir office in keeping hold of the support—not by any exertion of voluntary power which sleep might suspend, but by the traction of the tendons in consequence of the attitude which the legs and thighs take by the bird sitting down, and to which the mere weight of he body gives the force that is necessary.

VI. Regarding the human body as a mass; regarding the general conformations which obtain in it; regarding also particular parts in respect to those conformations; we shall be led to observe what I call "interrupted analogies." The following are examples of what I mean by these terms; and I do not know how such critical deviations can, by any possible hypothesis, be accounted for without design:

1. All the bones of the body are covered with a *periostium*, except the teeth, where it ceases; and an enamel of ivory, which saws and files will hardly touch, comes into its place. No one can doubt of the use and propriety of this difference; of the "analogy" being thus "interrupted;" of the rule, which belongs to the conformation of the bones stopping where it does stop; for, had so exquisitely sensible a membrane as the periostium invested the teeth as it invests every other bone of the body, their action, necessary exposure, and irritation, would have subjected the animal to continual pain. General as it is, it was not the sort of integument which suited the teeth; what they stood in need of was a strong, hard, insensible, defensive coat; and exactly such a covering is given to them in the ivory enamel which adheres to their surface."

2. The scarf-skin, which clothes all the rest of the body, gives way, at the extremities of the toes and fingers, to *nails*. A man has only to look at his hand to observe with what nicety and precision that covering, which extends over every other part, is here superseded by a different substance and a different texture. Now, if either the rule had been necessary, or the deviation from it accidental, this effect would not be seen. When I speak of the rule being necessary, I mean the formation of the skin upon the surface being produced by a set of causes constituted without design, and acting, as all ignorant causes must act, by a general operation. Were this the case, no account could be given of the operation being suspended at the fingers' ends, or on the back part of the fingers, and not on the fore part. On the other hand: if the deviation were accidental, an error, an anomalism—were it any thing else than settled by intention—we should meet with nails upon other parts of the body: they would be scattered over the surface like warts or pimples.

3. All the great cavities of the body are enclosed by membranes except the *skull*. Why should not the brain be content with the same covering as that which serves for the other principal organs of the body? The heart, the lungs, the liver, the stomach, the bowels, have all soft integuments, and nothing else. The muscular coats are all soft and membranous. I can see a reason for this distinction in the final cause, but in no other. The importance of the brain to life (which experience proves to be immediate,) and the

xtreme tenderness of its substance, make a solid case nore necessary for it than for any other part; and uch a case the hardness of the skull supplies. When he smallest portion of this natural casket is lost, how arefully, yet how imperfectly, is it replaced by a plate f metal! If an anatomist should say that this bony rotection is not confined to the brain, but is extended long the course of the spine, I answer that he adds trength to the argument. If he remark that the chest lso is fortified by bones, I reply that I should have lleged this instance myself if the ribs had not ap-eared subservient to the purpose of motion as well as f defence. What distinguishes the skull from every ther cavity is, that the bony covering completely sur-ounds its contents, and is calculated, not for motion, ut solely for defence. Those hollows, likewise, and equalities which we observe in the inside of the kull, and which exactly fit the folds of the brain, an-wer the important design of keeping the substance of e brain steady, and of guarding it against concussions

CHAPTER XII.

COMPARATIVE ANATOMY.

Whenever we find a general plan pursued, yet with ich variations in it as are, in each case, required by e particular exigency of the subject to which it is applied, we possess, in such a plan and such adaptation, the strongest evidence that can be afforded of intelligence and design: an evidence which the most completely excludes every other hypothesis. If the general plan proceeded from any fixed necessity in the nature of things, how could it accommodate itself to the various wants and uses which it had to serve under different circumstances and on different occasions? *Arkwright's* mill was invented for the spinning of cotton. We see it employed for the spinning of wool, flax, and hemp, with such modifications of the original principle, such variety in the same plan as the texture of those different materials rendered necessary. Of the machine's being put together with design, if it were possible to doubt whilst we saw it only under one mode, and in one form; when we came to observe it in its different applications, with such changes of structure, such additions and supplements, as the special and particular use in each case demanded, we could not refuse any longer our assent to the proposition—"that intelligence, properly and strictly so called, (including, under that name, foresight, consideration, reference to utility,) had been employed, as well in the primitive plan as in the several changes and accommodations which it is made to undergo."

Very much of this reasoning is applicable to what has been called *Comparative Anatomy.* In their general economy, in the outlines of the plan, in the construction as well as offices of their principal parts, there exists between all large terrestrial animals a close resemblance. In all, life is sustained, and the body nourished, by nearly the same apparatus. The heart, the lungs, the stomach, the liver, the kidneys, are much alike in all. The same fluid (for no distinction of blood has been observed) circulates through their vessels, and nearly in the same order. The same cause, therefore, whatever that cause was, has been concerned in the origin, has governed the production of these different animal forms.

When we pass on to smaller animals, or to the inhabitants of a different element, the resemblance becomes more distant and more obscure; but still the plan accompanies us.

And, what we can never enough commend, and which it is our business at present to exemplify, the plan is attended, through all its varieties and deflections, by subserviencies to special occasions and utilities.

1. The *covering* of different animals, (though whether I am correct in classing this under their anatomy, I do not know,) is the first thing which presents itself to our observation; and is, in truth, both for its variety and its suitableness to their several natures, as much to be admired as any part of their structure. We have bristles, hair, wool, furs, feathers, quills, prickles, scales; yet in this diversity both of material and form, we cannot change one animal's coat for another without evidently changing it for the worse; —taking care, however, to remark, that these coverings are, in many cases, armor as well as clothing; intended for protection and warmth.

The *human* animal is the only one which is naked, and the only one which can clothe itself. This is one of the properties which renders him an anima of all climates, and of all seasons. He can adapt th warmth or lightness of his covering to the tempera ture of his habitation. Had he been born with a fleec upon his back, although he might have been comfort ed by its warmth in high latitudes, it would have op pressed him by its weight and heat, as the specie spread towards the equator.

What art, however, does for men, nature has, in man instances, done for those animals which are incapa ble of art. Their clothing, of its own accord, change with their necessities. This is particularly the cas with that large tribe of quadrupeds which are covere with *furs*. Every dealer in hare-skins and rabbit skins knows how much the fur is thickened by th approach of winter. It seems to be a part of the sam constitution and the same design, that wool, in ho countries, degenerates, as it is called, but in truth (mos happily for the animal's ease) passes into hair: whilst on the contrary, that hair, in the dogs of the polar re gions, is turned into wool, or something very like it To which may be referred, what naturalists have re marked, that bears, wolves, foxes, hares, which do not take the water, have the fur much thicker on th back than the belly; whereas in the beaver it is th thickest upon the belly; as are the feathers in water fowl. We know the final cause of all this, and w know no other.

The *covering of birds* cannot escape the mos vulgar observation; its lightness, its smoothness, its warmth—the disposition of the feathers all inclined ackward, the down about their stem, the overlapping f their tips, their different configuration in different arts, not to mention the variety of their colors, contitute a vestment for the body, so beautiful, and so ppropriate to the life which the animal is to lead, as hat, I think, we should have had no conception of any hing equally perfect, if we had never seen it, or can ow imagine any thing more so. Let us suppose what is possible only in supposition) a person who ad never seen a bird, to be presented with a plucked heasant, and bid to set his wits to work how to conrive for it a covering which shall unite the qualities f warmth, levity, and least resistance to the air, and he highest degree of each; giving it also as much of eauty and ornament as he could afford. He is the erson to behold the work of the Deity, in this part of is creation, with the sentiments which are due to it.

The commendation which the general aspect of the eathered world seldom fails of exciting will be inreased by further examination. It is one of those ases in which the philosopher has more to admire han the common observer. Every *feather* is a mehanical wonder. If we look at the quill we find roperties not easily brought together—strength and ightness. I know few things more remarkable than he strength and lightness of the very pen with which am writing. If we cast our eye to the upper part of he stem, we see a material, made for the purpose, sed in no other class of animals, and in no other part f birds, tough, light, pliant, elastic. The pith also which feeds the feathers is, amongst animal substances, *sui generis*—neither bone, flesh, membrane, nor tendon.*

But the artificial part of a feather is the *beard*, or, as it is sometimes, I believe, called the vane. By the beards are meant what are fastened on each side of the stem, and what constitute the breadth of the feather, what we usually strip off from one side or both when we make a pen. The separate pieces, or laminæ, of which the beard is composed, are called threads, sometimes filaments or rays. Now, the first thing which an attentive observer will remark is, how much stronger the beard of the feather shows itself to be when pressed in a direction perpendicular to its plane, than when rubbed either up or down, in the line of the stem; and he will soon discover the structure which occasions this difference, viz. that the laminæ whereof these beards are composed are flat, and placed with their flat sides towards each other, by which means, whilst they *easily* bend for the approaching of each other, as any one may perceive by drawing his finger ever so lightly upwards, they are much harder to bend out of their plane, which is the direction in which they have to encounter the impulse and pressure of the air, and in which their strength is wanted and put to the trial.

This is one particularity in the structure of a feather; a second is still more extraordinary. Who-

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* The quill part of a feather is composed of circular and longitudinal fibres. In making a pen you must scrape off the coat of circular fibres, or the quill will split in a ragged, jagged manner; making what the boys call *cat's teeth.*

ever examines a feather cannot help taking notice, that the threads or laminæ of which we have been speaking, in their natural state, *unite*—that their union is something more than the mere apposition of loose surfaces—that they are not parted asunder without some degree of force—that nevertheless, there is no glutinous cohesion between them—that, therefore, by some mechanical means or other, they catch or clasp among themselves, thereby giving to the beard or vane its closeness and compactness of texture. Nor is this all; when two laminæ which have been separated by accident or force are brought together again, they immediately *reclasp*; the connection, whatever it was, is perfectly recovered, and the beard of the feather becomes as smooth and firm as if nothing had happened to it. Draw your finger down the feather which is against the grain, and you break probably the junction of some of the contiguous threads; draw your fingers up the feather, and you restore all things to their former state. This is no common contrivance: and now for the mechanism by which it is effected. The threads or laminæ above mentioned are *interlaced* with one another; and the interlacing is performed by means of a vast number of fibres or teeth, which the laminæ shoot forth *on each side*, and which hook and grapple together. A friend of mine counted fifty of these fibres in one twentieth of an inch. These fibres are crooked, but curved after a different manner; for those which proceed from the thread on the side towards the extremity of the feather are longer, more flexible, and bent downwards; whereas those which proceed from the side towards the beginning or quill end of the feather are shorter, firmer, and turn upwards. The process, then, which takes place is as follows: when two laminæ are pressed together, so that these long fibres are forced far enough over the short ones, their crooked parts fall into the cavity made by the crooked parts of the others, just as the latch that is fastened to a door enters into the cavity of the catch fixed to the door-post, and there hooking itself, fastens the door; for it is properly in this manner that one thread of a feather is fastened to the other.

This admirable structure of the feather, which it is easy to see with the microscope, succeeds perfectly for the use to which nature has designed it, which use was, not only that the laminæ might be united, but that, when one thread or laminæ has been separated from another by some external violence, it might be reclasped with sufficient facility and expedition.*

In the *ostrich* this apparatus of crotchets and fibres, of hooks and teeth, is wanting; and we see the consequence of the want. The filaments hang loose and separate from one another, forming only a kind of down, which constitution of the feathers, however it may fit them for the flowing honors of a lady's head-dress, may be reckoned an imperfection in the bird, inasmuch as wings composed of these feathers, although they may greatly assist it in running, do not serve for flight.

* The above account is taken from Memoirs for a Natural History of Animals, by the Royal Academy of Paris, published in 1701, p. 219.

But, under the present division of our subject, our business with feathers is as they are the *covering* of the bird. And herein a singular circumstance occurs. In the small order of birds which winter with us, from a snipe downwards, let the external color of the feathers be what it will, their Creator has universally given them a bed of *black* down next their bodies. Black, we know, is the warmest color; and the purpose here is, to *keep in* the heat arising from the heart and circulation of the blood. It is further likewise remarkable, that this is not found in larger birds; for which there is also a reason. Small birds are much more exposed to the cold than large ones, forasmuch as they present, in proportion to their bulk, a much larger surface to the air. If a turkey were divided into a number of wrens, (supposing the shape of the turkey and the wren to be similar,) the surface of all the wrens would exceed the surface of the turkey in the proportion of the length, breadth, (or of any homologous line,) of a turkey to that of a wren, which would be, perhaps, a proportion of ten to one. It was necessary, therefore, that small birds should be more warmly clad than large ones; and this seems to be the expedient by which that exigency is provided for.

II. In comparing different animals, I know no part of their structure which exhibits greater variety, or, in that variety, a nicer accommodation to their respective conveniency than that which is seen in the different formations of their *mouths*. Whether the purpose be the reception of aliment merely, or the catching of prey, the picking up of seeds, the cropping of herbage, the extraction of juices, the suction of liquids, the breaking and grinding of food, the taste of that food, together with the respiration of air, and in conjunction with it, the utterance of sound; these various offices are assigned to this one part, and, in different species, provided for as they are wanted by its different constitution. In the human species, forasmuch as there are hands to convey the food to the mouth, the mouth is flat, and by reason of its flatness, fitted only for *reception;* whereas the projecting jaws, the wide rictus, the pointed teeth, of the dog and his affinities, enable them to apply their mouths to *snatch and seize* the objects of their pursuit. The full lips, the rough tongue, the corrugated cartilaginous palate, the broad cutting teeth of the ox, the deer, the horse, and the sheep, qualify this tribe for *browsing* upon their pasture; either gathering large mouthfuls at once, where the grass is long, which is the case with the ox in particular, or biting close where it is short, which the horse and sheep are able to do in a degree that one would hardly expect. The retired under jaw of the swine *works in the ground,* after the protruding snout, like a prong or ploughshare, has made its way to the roots upon which it feeds. A conformation so happy was not the gift of chance.

In *birds* this organ assumes a new character; new both in substance and in form, but in both wonderfully adapted to the wants and uses of a distinct mode of existence. We have no longer the fleshy lips, the teeth of enamelled bone; but we have, in the place of these two parts, and to perform the office of both, a

ard substance, (of the same nature with that which
omposes the nails, claws, and hoofs of quadrupeds,)
ut out into proper shapes, and mechanically suited to
e actions which are wanted. The sharp edge and
mpered point of the *sparrow's* bill picks almost
ery kind of seed from its concealment in the plant,
d not only so, but hulls the grain, breaks and shat-
rs the coats of the seed, in order to get at the kernel.
he hooked beak of the hawk tribe separates the flesh
om the bones of the animals which it feeds upon,
most with the cleanness and precision of a dissec-
r's knife. The butcher-bird transfixes its prey upon
e spike of a thorn whilst it picks its bones. In some
rds of this class we have the *cross* bill, *i. e.* both the
per and lower bill hooked, and their tips crossing.
he *spoon* bill enables the goose to graze, to collect
food from the bottom of pools, or to seek it amidst
e soft or liquid substances with which it is mixed.
he *long* tapering bill of the snipe and woodcock pe-
trate still deeper into moist earth, which is the bed
which the food of that species is lodged. This is
actly the instrument which the animal wanted. It
d not want strength in its bill, which was inconsist-
t with the slender form of the animal's neck, as well
unnecessary for the kind of aliment upon which it
bsists; but it wanted length to reach its object.

But the species of bill which belongs to the birds
at live by *suction* deserves to be described in its re-
tion to that office. They are what naturalists call
rrated or dentated bills; the inside of them, towards
e edge, being thickly set with parallel or concentric

rows of short, strong, sharp-pointed prickles. Thes though they should be called teeth, are not for th purpose of mastication, like the teeth of quadrupeds nor yet, as in fish, for the seizing and retaining c their prey; but for a quite different use. They form filter. The *duck* by means of them discusses th mud; examining with great accuracy the puddle, th brake, every mixture which is likely to contain he food. The operation is thus carried on:—The liqui or semi-liquid substances in which the animal ha plunged her bill, she draws, by the action of he lungs, through the narrow interstices which lie be tween these teeth, catching, as the stream passes acros her beak, whatever it may happen to bring along wit it that proves agreeable to her choice, and easily dis missing all the rest. Now, suppose the purpose t have been, out of a mass of confused and heterogene ous substances, to separate for the use of the anima or rather to enable the animal to separate for its own those few particles which suited its taste and diges tion, what more artificial or more commodious instru ment of selection could have been given to it than thi natural filter? It has been observed also, (what mus enable the bird to choose and distinguish with greate acuteness, as well probably as what greatly increase its luxury,) that the bills of this species are furnishe with large nerves, that they are covered with a skin and that the nerves run down to the very extremity In the curlew, woodcock, and snipe, there are *thre pairs* of nerves, equal almost to the optic nerve i thickness, which pass first along the roof of the mout

nd then along the upper chap down to the point of
ıe bill, long as the bill is.

But to return to the train of our observations. The ;militude between the bills of birds and the mouths f quadrupeds is exactly such as, for the sake of the rgument, might be wished for. It is near enough to ıow the continuation of the same plan: it is remote ıough to exclude the supposition of the difference eing produced by action or use. A more prominent ɔntour, or a wider gap, might be resolved into the ffect of continued efforts, on the part of the species, › thrust out the mouth or open it to the stretch. But y what course of action, or exercise, or endeavor, ıall we get rid of the lips, the gums, the teeth, and cquire in the place of them pincers of horn? By ʳhat habit shall we so completely change, not only ıe shape of the part, but the substance of which it is ɔmposed? The truth is, if we had seen no other than ıe mouths of quadrupeds, we should have thought no ther could have been formed: little could we have upposed that all the purposes of a mouth furnished ʳith lips and armed with teeth could be answered by n instrument which had none of these—could be upplied, and that with many additional advantages, y the hardness, and sharpness, and figure of the bills f birds. Every thing about the animal *mouth* is me-hanical. The teeth of fish have their points turned ackward, like the teeth of a wool or cotton card. The teeth of lobsters work one against another, like he sides of a pair of shears. In many insects the nouth is converted into a pump or sucker, fitted at the end sometimes with a wimble, sometimes with forceps; by which double provision, viz. of the tub and the penetrating form of the point, the insect fir bores through the integuments of its prey, and the extracts the juices. And what is most extraordinary all, one sort of mouth, as the occasion requires, sha be changed into another sort. The caterpillar coul not live without teeth; in several species the butterfl formed from it could not use them. The old teetl therefore, are cast off with the exuviæ of the grub; new and totally different apparatus assumes the place in the fly. Amid these novelties of form, w sometimes forget that it is all the while the animal *mouth;* that, whether it be lips, or teeth, or bill, c beak, or shears, or pump, it is the same part divers fied; and it is also remarkable, that, under all the va rieties of configuration with which we are acquainted and which are very great, the organs of taste an smelling are situated near each other.

III. To the mouth adjoins the gullet: in this par also, comparative anatomy discovers a difference c structure adapted to the different necessities of the ani mal. In brutes, because the posture of their neck con duces little to the passage of the aliment, the fibres c the gullet which act in this business run in two clos spiral lines, crossing each other: in men these fibre run only a little obliquely from the upper end of th œsophagus to the stomach, into which, by a gentl contraction, they easily transmit the descending mor sels—that is to say, for the more laborious deglutitio of animals which thrust their food *up* instead of *down* nd also through a longer passage, a proportionably iore powerful apparatus of muscles is provided—iore powerful, not merely by the strength of the bres, which might be attributed to the greater exer-ise of their force, but in their collocation, which is a eterminate circumstance, and must have been original.

IV. The gullet leads to the *intestines:* here, like-ise, as before, comparing quadrupeds with man, nder a general similitude we meet with appropriate ifferences. The *valvulæ conniventes*, or, as they are y some called, the semi-lunar valves, found in the uman intestine, are wanting in that of brutes. These e wrinkles or plates of the innermost coat of the its, the effect of which is to retard the progress of ie food through the alimentary canal. It is easy to nderstand how much more necessary such a provi-on may be to the body of an animal of an erect pos-ire, and in which, consequently, the weight of the od is added to the action of the intestine, than in that a quadruped, in which the course of the food, from s entrance to its exit, is nearly horizontal; but it is npossible to assign any cause, except the final cause, r this distinction actually taking place. So far as epends upon the action of the part, this structure was ore to be expected in a quadruped than in a man. n truth, it must in both have been formed, not by ac-on, but in direct opposition to action and to pressure; it the opposition which would arise from pressure is eater in the trunk than in any other. That theory, erefore, is pointedly contradicted by the example be-re us. The structure is found where its generation according to the method by which the theorist wou have it generated, is the most difficult; but, obser it is found where its effect is most useful.

The different length of the intestines in carnivoro and herbivorous animals has been noticed on a form occasion. The shortest, I believe, is that of some bi of prey, in which the intestinal canal is little m than a straight passage from the mouth to the ve The longest is in the deer kind. The intestines o Canadian stag, four feet high, measured ninety- feet.* The intestine of a sheep, unravelled, measu thirty times the length of the body. The intestine o wild cat is only three times the length of the bo Universally, where the substance upon which the a mal feeds is of slow concoction, or yields its ch with more difficulty, there the passage is circuitous a dilatory, that time and space may be allowed for t change and the absorption which are necessa Where the food is soon dissolved, or already h assimilated, an unnecessary or perhaps hurtful dete tion is avoided, by giving to it a shorter and a re dier route.

V. In comparing the *bones* of different animals, are struck, in the bones of birds, with a *propriety* wh could only proceed from the wisdom of an intellig and designing Creator. In the bones of an anin which is to fly, the two qualities required are stren and lightness. Wherein, therefore, do the bones birds (I speak of the cylindrical bones) differ in th

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* Mem. Acad. Paris, 1701, p. 170.

pects from the bones of quadrupeds? In three pro-rties: first, their cavities are much larger in propor-n to the weight of the bone than in those of quad-peds; secondly, these cavities are empty; thirdly, shell is of a firmer texture than is the substance other bones. It is easy to observe other particulars en in picking the wing or leg of a chicken. Now weight being the same, the diameter, it is evident, ll be greater in a hollow bone than in a solid one, d with the diameter, as every mathematician can ove, is increased, *cæteris paribus*, the strength of cylinder or its resistance to breaking. In a word, a ne of the *same weight* would not have been so ong in any other form; and to have made it heavier uld have incommoded the animal's flight. Yet this m could not be acquired by use, or the bone become low or tubular by exercise. What appetency could avate a bone?

VI. The *lungs* also of birds, as compared with the gs of quadrupeds, contain in them a provision dis-guishingly calculated for this same purpose of levi-on, namely, a communication (not found in other ds of animals,) between the air-vessels of the lungs the cavities of the body; so that, by the intromis-n of air from one to the other, (at the will, as it uld seem, of the animal,) its body can be occasion- puffed out, and its tendency to descend in the air, ts specific gravity, made less. The bodies of birds blown up from their lungs, (which no other animal ies are,) and thus rendered buoyant.

II. All birds are *oviparous*. This likewise carries on the work of gestation with as little increase as p sible of the weight of the body. A gravid uter would have been a troublesome burden to a bird in flight. The advantage in this respect of an oviparo procreation is, that whilst the whole brood are hatch together, the eggs are excluded singly, and at consid rable intervals. Ten, fifteen, or twenty young bi may be produced in one cletch or covey, yet the par bird have never been encumbered by the load of m than one full-grown egg at one time.

VIII. A principal topic of comparison between a mals is in their *instruments of motion*. These co before us under three divisions—feet, wings, and fi I desire any man to say which of the three is b fitted for its use ; or whether the same consumm art be not conspicuous in them all. The constituti of the elements in which the motion is to be perfor ed is very different. The animal action must neces rily follow that constitution. The Creator, therefore we might so speak, had to prepare for different sit tions, for different difficulties; yet the purpose is complished not less successfully in one case than the other. And as between *wings* and the correspo ing limbs of quadrupeds, it is accomplished with deserting the general idea. The idea is modified, deserted. Strip a wing of its feathers, and it bears obscure resemblance to the fore-leg of a quadrup The articulations at the shoulder and the cubitus much alike; and, what is a closer circumstance, both cases the upper part of the limb consists of a s gle bone, the lower part of two.

But, fitted up with its furniture of feathers and ills, it becomes a wonderful instrument, more artifi-l than its first appearance indicates, though that be ry striking; at least, the use which the bird makes its wings in flying is more complicated and more rious than is generally known. One thing is certain, t if the flapping of the wings in flight were no more n the reciprocal motion of the same surface in oppo-e directions, either upwards and downwards, or esti-ted in any oblique line, the bird would lose as much one motion as she gained by another. The skylark ld never ascend by such an action as this; for, ugh the stroke upon the air by the underside of her ng would carry her up, the stroke from the upper e, when she raised her wing again, would bring down. In order, therefore, to account for the ad-ntage which the bird derives from her wing, it is essary to suppose that the surface of the wing, asured upon the same plane, is contracted, whilst wing is drawn up; and let out to its full expan-n, when it descends upon the air for the purpose of ving the body by the re-action of that element. w, the form and structure of the wing, its external vexity, the disposition, and particularly the over-ping, of its larger feathers, the action of the muscles joints of the pinions, are all adapted to this alter-e adjustment of its shape and dimensions. Such a st, for instance, or semi-rotatory motion, is given to great feathers of the wing, that they strike the air h their flat side, but rise from the stroke slantwise. e turning of the oar in rowing, whilst the rower advances his hand for a new stroke, is a similar o ration to that of the feather, and takes its name fr the resemblance. I believe that this faculty is found in the great feathers of the tail. This is place also for observing that the pinions are so upon the body as to bring down the wings not ve cally, but in a direction obliquely tending towards tail;—which motion, by virtue of the common reso tion of forces, does two things at the same time—s ports the body in the air, and carries it forward. T *steerage* of a bird in its flight is effected partly the wings, but in a principal degree by the tail. A herein we meet with a circumstance not a little markable. Birds with long legs have short tails; a in their flight place their legs close to their bodies, the same time stretching them out backwards as far they can. In this position the legs extend beyond rump, and become the rudder; supplying that steera which the tail could not.

From the *wings* of birds the transition is easy the *fins* of fish. They are both, to their respect tribes, the instruments of their motion; but, in work which they have to do there is a considera difference, founded in this circumstance. Fish, unl birds, have very nearly the same specific gravity w the element in which they move. In the case of fi therefore, there is little or no weight to bear up; w is wanted is only an impulse sufficient to carry body through a resisting medium, or to maintain posture, or to support or restore the balance of body, which is always the most unsteady where th no weight to sink it. For these offices the fins are large as necessary, though much smaller than ngs; their action mechanical, their position and the iscles by which they are moved in the highest de- ee convenient. The following short account of some periments upon fish, made for the purpose of ascer- ning the use of their fins, will be the best confirma- n of what we assert. In most fish, besides the great , the tail, we find two pairs of fins upon the sides, o single fins upon the back, and one upon the belly, rather between the belly and the tail. The *ba- cing* use of these organs is proved in this manner. the large-headed fish, if you cut off the pectoral s—*i. e.* the pair which lies close behind the gills— head falls prone to the bottom: if the right pec- al fin only be cut off, the fish leans to that side; if ventral fin on the same side be cut away, then it es its equilibrium entirely; if the dorsal and ven- fins be cut off, the fish reels to the right and left. hen the fish dies, that is, when the fins cease to ly, the belly turns upwards. The use of the same ts for *motion* is seen in the following observation n them when put in action. The pectoral, and re particularly the ventral fins, served to *raise and ress* the fish; when the fish desires to have a *re- grade* motion, a stroke forward with the pectoral effectually produces it; if the fish desire to *turn* ler way, a single blow with the tail the opposite y sends it round at once; if the tail strike both ys, the motion produced by the double lash is *pro- ssive*, and enables the fish to dart forward with an

astonishing velocity.* The result is, not only in so
cases the most rapid, but in all cases the most gent
pliant, easy, animal motion with which we are
quainted. However, when the tail is cut off the f
loses all motion, and gives itself up to where the wa
impels it. The rest of the fins, therefore, so far as
spects motion, seem to be merely subsidiary to this.
their mechanical use, the anal fin may be reckon
the keel; the ventral fins, out-riggers; the pecto
muscles, the oars; and if there be any similitude
tween these parts of a boat and a fish, observe, tha
is not the resemblance of imitation, but the liken
which arises from applying similar mechanical mea
to the same purpose.

We have seen that the *tail* in the fish is the gr
instrument of motion. Now, in cetaceous or war
blooded fish, which are obliged to rise every two
three minutes to the surface to take breath, the ta
unlike what it is in other fish, is horizontal; its strol
consequently, perpendicular to the horizon, which
the right direction for sending the fish to the top,
carrying it down to the bottom.

Regarding animals in their instruments of moti
we have only followed the comparison through t
first great division of animals into beasts, birds a
fish. If it were our intention to pursue the conside
tion further, I should take in that generic distincti
amongst birds, the *web-foot* of water-fowl. It is an
stance which may be pointed out to a child. T

* Goldsmith, Hist. of An. Nat. vol. 6, p. 154.

ıtility of the web to water-fowl, the inutility to land-owl, are so obvious, that it seems impossible to notice he difference without acknowledging the design. I m at a loss to know how those who deny the agency f an intelligent Creator dispose of this example. There is nothing in the action of swimming, as car-ied on by a bird upon the surface of the water, that hould generate a membrane between the toes. As to ıat membrane, it is an exercise of constant resistance. The only supposition I can think of is, that all birds ave been originally water-fowl, and web-footed; that parrows, hawks, linnets, &c. which frequent the ınd, have, in process of time, and in the course of ıany generations, had this part worn away by tread-ıg upon hard ground. To such evasive assumptions ıust atheism always have recourse! And after all, it onfesses that the structure of the feet of birds, in their riginal form, was critically adapted to their original estination! The web-feet of amphibious quadrupeds, eals, otters, &c. fell under the same observation.

IX. The *five senses* are common to most large ani-ıals; nor have we much difference to remark in their onstitution, or much, however, which is referable to ıechanism.

The superior sagacity of animals which hunt their rey, and which, consequently, depend for their liveli-ood upon their *nose*, is well known in its use; but not all known in the organization which produces it.

The external *ears* of beasts of prey, of lions, tigers, olves, have their trumpet-part, or concavity, standing rward, to seize the sounds which are before them—

viz. the sounds of the animals which they pursue or watch. The ears of animals of flight are turned backward, to give notice of the approach of their enemy from behind, whence he may steal upon them unseen. This is a critical distinction, and is mechanical; but it may be suggested, and I think not without probability, that it is the effect of continual habit.

The *eyes* of animals which follow their prey by night, as cats, owls, &c. possess a faculty not given to those of other species, namely, of closing the pupil *entirely*. The final cause of which seems to be this: It was necessary for such animals to be able to descry objects with very small degrees of light. This capacity depended upon the superior sensibility of the retina; that is, upon its being effected by the most feeble impulses. But that tenderness of structure which rendered the membrane thus exquisitely sensible, rendered it also liable to be offended by the access of stronger degrees of light. The contractile range therefore of the pupil is increased in these animals, so as to enable them to close the aperture entirely, which includes the power of diminishing it in every degree; whereby at all times such portions, and only such portions of light are admitted, as may be received without injury to the sense.

There appears to be also in the figure, and in some properties of the pupil of the eye, an appropriate relation to the wants of different animals. In horses, oxen, goats, sheep, the pupil of the eye is elliptical; the transverse axis being horizontal; by which structure, although the eye be placed on the side of the head, the anterior elongation of the pupil catches the forward rays, or those which come from objects immediately in front of the animal's face.

CHAPTER XIII.

PECULIAR ORGANIZATIONS.

I believe that all the instances which I shall colect under this title might, consistently enough with echnical language, have been placed under the head f *Comparative Anatomy*. But there appears to me n impropriety in the use which that term hath obined; it being, in some sort, absurd to call that a ase of comparative anatomy, in which there is nothing "compare;" in which a conformation is found in e animal which hath nothing properly answering it in another. Of this kind are the examples which have to propose in the present chapter; and the ader will see that, though some of them be the rongest, perhaps, he will meet with under any dividon of our subject, they must necessarily be of an nconnected and miscellaneous nature. To dispose em, however, into some sort of order, we will notice rst, particularities of structure which belong to quadpeds, birds and fish, as such, or to many of the kinds cluded in these classes of animals; and then, such rticularities as are confined to one or two species.

I. Along each side of the neck of large *quadrupec* runs a stiff robust cartilage, which butchers call th pax-wax. No person can carve the upper end of crop of beef without driving his knife against it. It a tough, strong, tendinous substance, braced from th head to the middle of the back; its office is to assist i supporting the weight of the head. It is a mechanic provision, of which this is the undisputed use; and is sufficient, and not more than sufficient for the pu pose which it has to execute. The head of an ox c a horse is a heavy weight, acting at the end of a lon lever (consequently with a great purchase) and in direction nearly perpendicular to the joints of the sup porting neck. From such a force, so advantageousl applied, the bones of the neck would be in constan danger of dislocation if they were not fortified by thi strong tape. No such organ is found in the huma subject, because, from the erect position of the hea (the pressure of it acting nearly in the direction of th spine) the junction of the vertebræ appears to be suffi ciently secure without it. This cautionary expedien therefore, is limited to quadrupeds; the care of th Creator is seen where it is wanted.

II. The oil with which *birds* preen their feather and the organ which supplies it, is a specific provisio for the winged creation. On each side of the rum of birds is observed a small nipple, yielding upon pres sure a butter-like substance, which the bird extract by pinching the pap with its bill. With this oil c ointment, thus procured, the bird dresses his coat; an repeats the action as often as its own sensations teac it that it is in any part wanted, or as the excretion may be sufficient for the expense. The gland, the pap, the nature and quality of the excreted substance, the manner of obtaining it from its lodgement in the body, the application of it when obtained, form, collectively, an evidence of intention which it is not easy to withstand. Nothing similar to it is found in unfeathered animals. What blind *conatus* of nature should produce it in birds; should not produce it in beasts?

III. The air-bladder also of a *fish* affords a plain and direct instance, not only of contrivance, but strictly of that species of contrivance which we denominate mechanical. It is a philosophical apparatus in the body of an animal. The principle of the contrivance is clear: the application of the principle is also clear. The use of the organ to sustain, and, at will, also to elevate, the body of the fish in the water, is proved by observing what has been tried, that, when the bladder is burst the fish grovels at the bottom; and also, that flounders, soles, skates, which are without the air-bladder, seldom rise in the water, and that with effort. The manner in which the purpose is attained, and the suitableness of the means to the end, are not difficult to be apprehended. The rising and sinking of a fish in water, so far as it is independent of the stroke of the fins and tail, can only be regulated by the specific gravity of the body. When the bladder, contained in the body of a fish, is contracted, which the fish probably possesses a muscular power of doing, the bulk of the fish is contracted along with it; whereby, since the absolute weight remains the same, the specific gravity, which is the sinking force, is increased, and the fish descends: on the contrary, when, in consequence of the relaxation of the muscles, the elasticity of the enclosed and now compressed air restores the dimensions of the bladder, the tendency downwards becomes proportionably less than it was before, or is turned into a contrary tendency. These are known properties of bodies immersed in a fluid. The enamelled figures, or little glass bubbles, in a jar of water, are made to rise and fall by the same artifice. A diving-machine might be made to ascend and descend, upon the like principle; namely, by introducing into the inside of it an air-vessel, which by its contraction would diminish, and by its distention enlarge, the bulk of the machine itself, and thus render it specifically heavier or specifically lighter than the water which surrounds it. Suppose this to be done, and the artist to solicit a patent for his invention: the inspectors of the model, whatever they might think of the use or value of the contrivance, could by no possibility entertain a question in their minds, whether it were a contrivance or not. No reason has ever been assigned,—no reason can be assigned, why the conclusion is not as certain in the fish as it is in the machine; why the argument is not as firm in one case as the other.

It would be very worthy of inquiry if it were possible to discover, by what method an animal which lives constantly in water is able to supply a repository of air. The expedient, whatever it be, forms part, and perhaps the most curious part of the provision. No hing similar to the air-bladder is found in land-animals; and a life in the water has no natural tendency o produce a bag of air. Nothing can be further from n acquired organization than this is.

These examples mark the attention of the Creator to he three great kingdoms of his animal creation, and o their constitution as such. The example which tands next in point of generality, belonging to a large ribe of animals, or rather to various species of that ribe, is the poisonous tooth of serpents.

I. The *fang of a viper* is a clear and curious example of mechanical contrivance. It is a perforated ooth, loose at the root: in its quiet state, lying down lat upon the jaw, but furnished with a muscle, which, vith a jerk, and by the pluck, as it were, of a string, uddenly erects it. Under the tooth, close to its root, ind communicating with the perforation, lies a small bag containing the venom. When the fang is raised he closing of the jaw presses its root against the bag inderneath; and the force of this compression sends out the fluid with a considerable impetus through the ube in the middle of the tooth. What more unequivocal or effectual apparatus could be devised for the louble purpose of at once inflicting the wound and injecting the poison? Yet, though lodged in the mouth, it is so constituted, as, in its inoffensive and quiescent state, not to interfere with the animal's ordinary office of receiving its food. It has been observed, also, that none of the harmless serpents, the black snake, the blind worm, &c. have these fangs, but teeth of an equal size: not moveable as this is, but fixed into the jaw.

II. In being the property of several different species, the preceding example is resembled by that which I shall next mention, which is the *bag of the opossum*. This is a mechanical contrivance, most properly so called. The simplicity of the expedient renders the contrivance more obvious than many others, and by no means less certain. A false skin under the belly of the animal forms a pouch into which the young litter are received at their birth; where they have an easy and constant access to the teats; in which they are transported by the dam from place to place; where they are at liberty to run in and out; and where they find a refuge from surprise and danger. It is their cradle, their asylum and the machine for their conveyance. Can the use of this structure be doubted of? Nor is it a mere doubling of the skin; but is a new organ, furnished with bones and muscles of its own. Two bones are placed before the os pubis, and joined to that bone as their base. These support and give a fixture to the muscles which serve to open the bag. To these muscles there are antagonists, which serve in the same manner to shut it; and this office they perform so exactly, that, in the living animal, the opening can scarcely be discerned, except when the sides are forcibly drawn asunder.* Is there any action in this part of the animal, any process arising from that action, by which these members could be formed? any account to be given of the formation, except design?

III. As a particularity, yet appertaining to more

* Goldsmith, Nat. Hist. vol. 4, p. 244.

pecies than one, and also as strictly mechanical, we ıay notice a circumstance in the structure of the *claws* f certain birds. The middle claw of the heron and ormorant is toothed and notched like a saw. These irds are great fishers, and these notches assist them n holding their slippery prey. The use is evident; ut the structure such as cannot at all be accounted or by the effort of the animal, or the exercise of the art. Some other fishing birds have these notches in heir *bills;* and for the same purpose. The gannet, or Soland goose, has the side of its bill irregularly jagged, hat it may hold its prey the faster. Nor can the tructure of this, more than in the former case, arise rom the manner of employing the part. The smooth urfaces, and soft flesh of fish, were less likely to notch he bills of birds, than the hard bodies upon which nany other species feed.

We now come to the particularities strictly so called, as being limited to a single species of animal. Of hese, I shall take one from a quadruped, and one rom a bird.

I. The *stomach of the camel* is well known to re-ain large quantities of water, and to retain it un-changed for a considerable length of time. This property qualifies it for living in the desert. Let us see, therefore, what is the internal organization upon which a faculty so rare and so beneficial depends. A number of distinct sacs or bags (in a dromedary thirty of these have been counted) are observed to lie be-tween the membranes of the second stomach, and to open into the stomach near the top by small square apertures. Through these orifices, after the stomach is full, the annexed bags are filled from it: and the water so deposited is, in the first place, not liable to pass into the intestines; in the second place, is kept separate from solid aliment; and, in the third place, is out of the reach of the digestive action of the stomach, or of mixture with the gastric juice. It appears probable, or rather certain, that the animal, by the conformation of its muscles, possesses the power of squeezing back this water from the adjacent bags into the stomach, whenever thirst excites it to put this power in action.

II. The *tongue of the woodpecker* is one of those singularities, which nature presents us with, when a singular purpose is to be answered. It is a particular instrument for a particular use; and what, except design, ever produces such? The woodpecker lives chiefly upon insects lodged in the bodies of decayed or decaying trees. For the purpose of boring into the wood, it is furnished with a bill straight, hard, angular, and sharp. When, by means of this piercer it has reached the cells of the insects, then comes the office of its tongue; which tongue is, first, of such a length that the bird can dart it out three or four inches from the bill,—in this respect differing greatly from every other species of bird; in the second place, it is tipped with a stiff, sharp, bony thorn; and, in the third place, (which appears to me the most remarkable property of all,) this tip is dentated on both sides like the beard of an arrow or the barb of a hook. The description of the part declares its uses. The bird, having exposed the retreats of the insects by the assistance of its bill, with a motion inconceivably quick, launches out at them this long tongue; transfixes them upon the barbed needle at the end of it; and thus draws its prey within its mouth. If this be not mechanism, what is? Should it be said, that by continual endeavors to shoot out the tongue to the stretch, the woodpecker species may by degrees have lengthened the organ itself beyond that of other birds, what account can be given of its form, of its tip? how, in particular, did it get its barb, its dentation? These barbs, in my opinion, wherever they occur, are decisive proofs of mechanical contrivance.

III. I shall add one more example, for the sake of its novelty. It is always an agreeable discovery, when, having remarked in an animal an extraordinary structure, we come at length to find out an unexpected use for it. The following narrative furnishes an instance of this kind. The babyroussa, or Indian hog, a species of wild boar, found in the East Indies, has two *bent* teeth, more than half a yard long, growing upwards, and (which is the singularity) from the upper jaw. These instruments are not wanted for offence; that service being provided for by two tusks issuing from the under jaw, and resembling those of the common boar: nor does the animal use them for defence. They might seem, therefore, to be both a superfluity and an incumbrance. But observe the event:—the animal sleeps standing; and in order to support its head, hooks its upper tusks upon the branches of trees.

CHAPTER XIV.

PROSPECTIVE CONTRIVANCES.

I can hardly imagine to myself a more distinguish ing mark, and, consequently, a more certain proof o design, than *preparation*,—*i. e.* the providing of thing beforehand, which are not to be used for a considera ble time afterwards: for this implies a contemplatio of the future, which belongs only to intelligence.

Of these *prospective* contrivances the bodies of ani mals furnish various examples.

I. The human teeth afford an instance, not only o prospective contrivance, but of the completion of th contrivance being designedly suspended. They ar formed within the gums, and there they stop; th fact being, that their farther advance to maturity woul not only be useless to the new-born animal, but ex tremely in its way; as it is evident that the act o *sucking*, by which it is for some time to be nourished will be performed with more ease both to the nurs and to the infant, whilst the inside of the mouth an edges of the gums are smooth and soft, than if se with hard-pointed bones. By the time they are want ed the teeth are ready. They have been lodged withi the gums for some months past, but detained, as i were, in their sockets, so long as their farther protru sion would interfere with the office to which the mouth is destined. Nature, namely, that intelligence which was employed in creation, looked beyond the first yea of the infant's life: yet, whilst she was providing for functions which were after that term to become necessary, was careful not to incommode those which preceded them. What renders it more probable that this is the effect of design, is, that the teeth are imperfect, whilst all other parts of the mouth are perfect. The lips are perfect, the tongue is perfect; the cheeks, the jaws, the palate, the pharynx, the larynx, are all perfect: the teeth alone are not so. This is the fact with respect to the human mouth: the fact also is, that the parts above enumerated are called into use from the beginning; whereas the teeth would be only so many obstacles and annoyances if they were there. When a contrary order is necessary, a contrary order prevails. In the worm of the beetle, as hatched from the egg, the teeth are the first things which arrive at perfection. The insect begins to gnaw as soon as it escapes from the shell, though its other parts be only gradually advancing to their maturity.

What has been observed of the teeth is true of the *horns* of animals; and for the same reason. The horn of a calf or a lamb does not bud, or at least does not sprout to any considerable length, until the animal be capable of browsing upon its pasture; because such a substance upon the forehead of the young animal would very much incommode the teat of the dam in the office of giving suck.

But in the case of the *teeth*—of the human teeth at least, the prospective contrivance looks still farther. A succession of crops is provided, and provided from the beginning; a second tier being originally formed beneath the first, which do not come into use till several years afterwards. And this double or suppletory provision meets a difficulty in the mechanism of the mouth, which would have appeared almost insurmountable. The expansion of the jaw (the consequence of the proportionable growth of the animal and of its skull) necessarily separates the teeth of the first set, however compactly disposed, to a distance from one another, which would be very inconvenient. In due time, therefore, *i. e.* when the jaw has attained a great part of its dimensions, a new set of teeth springs up, (loosening and pushing out the old ones before them,) more exactly fitted to the space which they are to occupy, and rising also in such close ranks as to allow for any extension of line which the subsequent enlargement of the head may occasion.

II. It is not very easy to conceive a more evidently prospective contrivance than that which, in all viviparous animals, is found in the *milk* of the female parent. At the moment the young animal enters the world there is its maintenance ready for it. The particulars to be remarked in this economy are neither few nor slight. We have, first, the nutritious quality of the fluid, unlike, in this respect, every other excretion of the body: and in which nature hitherto remains unimitated, neither cookery nor chemistry having been able to make milk out of grass: we have, secondly, the organ for its reception and retention: we have, thirdly, the excretory duct annexed to that organ: and we have, lastly, the determination of the milk to the breast at the particular juncture when it is about to be wanted. We have all these properties in the subject before us; and they are all indications of design. The last circumstance is the strongest of any. If I had been to guess beforehand, I should have conjectured, that at the time when there was an extraordinary demand for nourishment in one part of the system, there would be the least likelihood of a redundancy to supply another part. The advanced pregnancy of the female has no intelligible tendency to fill the breasts with milk. The lacteal system is a constant wonder; and it adds to other causes of our admiration, that the number of the teats or paps in each species is found to bear a proportion to the number of the young. In the sow, the bitch, the rabbit, the cat, the rat, which have numerous litters, the paps are numerous, and are disposed along the whole length of the belly: in the cow and mare they are few. The most simple account of this is to refer it to a designing Creator.

But in the argument before us, we are entitled to consider not only animal bodies when framed, but the circumstance under which they are framed: and in this view of the subject the constitution of many of their parts is most strictly prospective.

III. The eye is of no use, at the time when it is formed. It is an optical instrument made in a dungeon; constructed for the refraction of light to a focus, and perfect for its purpose before a ray of light has had access to it; geometrically adapted to the properties and action of an element with which it has no communication. It is about indeed to enter into that communication: and this is precisely the thing which evidences intention. It is *providing* for the *future* in the closest sense which can be given to these terms; for it is providing for a future change; not for the then subsisting condition of the animal; not for any gradual progress or advance in that same condition; but for a new state, the consequence of a great and sudden alteration which the animal is to undergo at its birth. Is it to be believed that the eye was formed, or, which is the same thing, that the series of causes was fixed by which the eye is formed, without a view to this change; without a prospect of that condition, in which its fabric, of no use at present, is about to be of the greatest; without a consideration of the qualities of that element, hitherto entirely excluded, but with which it was hereafter to hold so intimate a relation? A young man makes a pair of spectacles for himself against he grows old; for which spectacles he has no want or use whatever at the time he makes them. Could this be done without knowing and considering the defect of vision to which advanced age is subject? Would not the precise suitableness of the instrument to its purpose, of the remedy to the defect, of the convex lens to the flattened eye, establish the certainty of the conclusion, that the case, afterwards to arise, had been considered beforehand, speculated upon, provided for? all which are exclusively the acts of a reasoning mind. The eye formed in one state, for use only in another state, and in a different state, affords a proof no less clear of destination to a future purpose; and a proof proportionably stronger, as the machinery is more complicated and the adaptation more exact.

IV. What has been said of the eye, holds equally true of the lungs. Composed of air-vessels, where there is no air; elaborately constructed for the alternate admission and expulsion of an elastic fluid, where no such fluid exists; this great organ, with the whole apparatus belonging to it, lies collapsed in the fœtal thorax; yet in order, and in readiness for action, the first moment that the occasion requires its service. This is having a machine locked up in store for future use; which incontestably proves that the case was expected to occur in which this use might be experienced; but expectation is the proper act of intelligence. Considering the state in which an animal exists before its birth, I should look for nothing less in its body than a system of lungs. It is like finding a pair of bellows in the bottom of the sea; of no sort of use in the situation in which they are found; formed for an action which was impossible to be exerted; holding no relation or fitness to the element which surrounds them, but both to another element in another place.

As part and parcel of the same plan ought to be mentioned, in speaking of the lungs, the provisionary contrivances of the *foramen ovale* and *ductus arteriosus*. In the fœtus pipes are laid for the passage of the blood through the lungs; but until the lungs be inflated by the inspiration of air, that passage is impervious, or in a great degree obstructed. What then is to be done? What would an artist, what would a master do upon the occasion? He would endeavor, most probably, to provide a *temporary* passage, which might carry on the communication required, until the other was open. Now this is the thing which actually done in the heart. Instead of the circuitou route through the lungs which the blood afterwarc takes before it gets from one auricle of the heart to th other, a portion of the blood passes immediately fro the right auricle to the left, through a hole placed i the partition which separates these cavities. This hol anatomists call the *foramen ovale.* This is likewis another cross cut, answering the same purpose, b what is called the *ductus arteriosus*, lying between th pulmonary artery and the aörta. But both expedient are so strictly temporary, that after birth the one pas sage is closed, and the tube which forms the othe shrivelled up into a ligament. If this be not con trivance, what is?

But, forasmuch as the action of the air upon th blood in the lungs appears to be necessary to the pe fect concoction of that fluid, *i. e.* to the life and healt of the animal, (otherwise the shortest route might stil be the best,) how comes it to pass that the *fœtus* lives and grows, and thrives without it? The answer is that the blood of the fœtus is the mother's; that it ha undergone that action in her habit; that one pair o lungs serves for both. When the animals are separate a new necessity arises; and to meet this necessity a soon as it occurs an organization is prepared. It i ready for its purpose; it only waits for the atmosphere it begins to play the moment the air is admitted to it

CHAPTER XV.

RELATIONS.

When several different parts contribute to one effect, r, which is the same thing, when an effect is produc- l by the joint action of different instruments ; the fit- ess of such parts or instruments to one another for the urpose of producing, by their united action, the effect, what I call *relation* ; and wherever this is observed the works of nature or of man, it appears to me to urry along with it decisive evidence of understanding, tention, art. In examining, for instance, the several rts of a *watch*, the spring, the barrel, the chain, the see, the balance, the wheels of various sizes, forms, ud positions, what is it which would take an ob- rver's attention as most plainly evincing a construc- on, directed by thought, deliberation, and contrivance? is the suitableness of these parts to one another ; first, the succession and order in which they act ; and, condly, with a view to the effect finally produced. hus, referring the spring to the wheels, our observer es in it that which originates and upholds *their* mo- n ; in the chain, that which transmits the motion to e fusee ; in the fusee, that which communicates it to e wheels ; in the conical figure of the fusee, if he er to the spring, he sees that which corrects the in- uality of its force. Referring the wheels to one an- her, he notices, first, their teeth, which would have en without use or meaning if there had been only one wheel, or if the wheels had had no connection be- tween themselves, or common bearing upon some join effect; secondly, the correspondency of their positio so that the teeth of one wheel catch into the teeth another; thirdly, the proportion observed in the num ber of teeth in each wheel, which determines the ra of going. Referring the balance to the rest of th works, he saw, when he came to understand its actio that which rendered their motions equable. Lastl in looking upon the index and face of the watch, l saw the use and conclusion of the mechanism, vi marking the succession of minutes and hours; but a depending upon the motions within, all upon the sy tem of intermediate actions between the spring and th pointer. What thus struck his attention in the sev ral parts of the watch he might probably desi nate by one general name of "relation;" and observin with respect to all cases whatever, in which the o gin and formation of a thing could be ascertained l evidence, that these relations were found in things pr duced by art and design, and in no other things, l would rightly deem of them as characteristic of su productions. To apply the reasoning here describ to the works of nature.

The animal economy is full, is made up, of the *relations.*

I. There are, first, what in one form or other belo to all animals, the parts and powers which succ sively act upon their *food.* Compare this action wi the process of a manufactory. In men and quadr peds the aliment is first broken and bruised by m hanical instruments of mastication, viz. sharp spikes r hard knobs, pressing against or rubbing upon one nother; thus ground and comminuted it is carried by a ipe into the stomach, where it waits to undergo a great hymical action, which we call digestion: when di- ested it is delivered through an orifice, which opens nd shuts, as there is occasion, into the first intestine; here, after being mixed with certain proper ingredi- nts, poured through a hole in the side of the vessel, is further dissolved: in this state the milk, chyle, or art which is wanted, and which is suited for animal ourishment, is strained off by the mouths of very mall tubes opening into the cavity of the intestines; us freed from its grosser parts, the percolated fluid is arried by a long, winding, but traceable course, into e main stream of the old circulation; which conveys in its progress to every part of the body. Now I ay again, compare this with the process of a manu- ctory, with the making of cider, for example; with the ruising of the apples in the mill, the squeezing of em when so bruised in the press, the fermentation the vat, the bestowing of the liquor thus fermented the hogsheads, the drawing off into bottles, the ouring out for use into the glass. Let any one show e any difference between these two cases as to the oint of contrivance. That which is at present under ur consideration, the "relation" of the parts succes- vely employed, is not more clear in the last case than the first. The aptness of the jaws and teeth to pre- are the food for the stomach is, at least, as manifest s that of the cider-mill to crush the apples for the press. The concoction of the food in the stomach is as necessary for its future use as the fermentation of the stum in the vat is to the perfection of the liquor. The disposal of the aliment afterwards, the action and change which it undergoes, the route which it is made to take, in order that, and until that, it arrive at its destination, is more complex indeed and intricate, but, in the midst of complication and intricacy, as evident and certain as is the apparatus of cocks, pipes, tunnels, for transferring the cider from one vessel to another; or barrels and bottles for preserving it till fit for use, or of cups and glasses for bringing it when wanted to the lip of the consumer. The character of the machinery is in both cases this,—that one part answers to another part, and every part to the final result.

This parallel between the alimentary operation and some of the processes of art might be carried further into detail. Spallanzani has remarked* a circumstantial resemblance between the stomachs of gallinaceous fowls and the structure of *corn-mills*. Whilst the two sides of the gizzard perform the office of the mill-stones, the craw or crop supplies the place of the *hopper*.

When our fowls are abundantly supplied with meat they soon fill their craw; but it does not immediately pass thence into the gizzard; it always enters in very small quantities, in proportion to the progress of trituration, in like manner as, in a mill, a receiver is fixed above the two large stones which serve for grinding

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* Disc. 1. sec. 54.

the corn, which receiver, although the corn be put into it in bushels, allows the grain to dribble only in small quantities into the central hole in the upper mill-stone.

But we have not done with the alimentary history. There subsists a general *relation* between the external organs of an animal by which it procures its food and the internal powers by which it digests it. Birds of prey, by their talons and beaks, are qualified to seize and devour many species both of other birds and of quadrupeds. The constitution of the stomach agrees exactly with the form of the members. The gastric juice of a bird of prey, of an owl, a falcon, or a kite, acts upon the animal fibre alone; it will not act upon seeds or grasses at all. On the other hand, the conformation of the mouth of the sheep or the ox is suited for browsing upon herbage. Nothing about these animals is fitted for the pursuit of living prey. Accordingly it has been found, by experiments tried not many years ago, with perforated balls, that the gastric juice of ruminating animals, such as the sheep and the ox, speedily dissolves vegetables, but makes no impression upon animal bodies. This accordancy is still more particular. The gastric juice, even of granivorous birds, will not act upon the grain whilst whole and entire. In performing the experiment of digesting with the gastric juice in vessels, the grain must be crushed and bruised before it be submitted to the menstruum, that is to say, must undergo by art, without the body, the preparatory action which the gizzard exerts upon it within the body, or no digestion will take place. So strict, in this case, is the relation between the offices assigned to the digestive organ, between the mechanical operation and the chemical process.

II. The relation of the kidneys to the bladder, and of the ureters to both, *i. e.* of the secreting organ to the vessel receiving the secreted liquor, and the pipe laid from one to the other for the purpose of conveying it from one to the other, is as manifest as it is amongst the different vessels employed in a distillery, or in the communications between them. The animal structure, in this case, being simple, and the parts easily separated, it forms an instance of correlation which may be presented by dissection to every eye, or which indeed without dissection is capable of being apprehended by every understanding. This correlation of instruments to one another fixes intention somewhere: especially when every other solution is negatived by the conformation. If the bladder had been merely an expansion of the ureter, produced by retention of the fluid, there ought to have been a bladder for each ureter. One receptacle fed by two pipes issuing from different sides of the body, yet from both conveying the same fluid, is not to be accounted for by any such supposition as this.

III. Relation of parts to one another accompanies us throughout the whole animal economy. Can any relation be more simple, yet more convincing than this, that the eyes are so placed as to look in the direction in which the legs move and the hands work? It might have happened very differently if it had been left to chance. There were at least three quarters of ıe compass out of four to have erred in. Any consi-erable alteration in the position of the eye or the gure of the joints would have disturbed the line and estroyed the alliance between the sense and the limbs.

IV. But relation, perhaps, is never so striking as when it subsists, not between different parts of the ame thing, but between different things. The relation etween a lock and a key is more obvious than it is etween different parts of the lock. A bow was design-d for an arrow, and an arrow for a bow; and the esign is more evident for their being separate im-lements.

Nor do the works of the Deity want the clearest pecies of relation. The *sexes* are manifestly made for ach other. They form the grand relation of animated ature; universal, organic, mechanical; subsisting, like ıe clearest relations of art, in different individuals, nequivocal, inexplicable, without design.

So much so, that, were every other proof of con-rivance in nature dubious or obscure, this alone would e sufficient. The example is complete. Nothing is vanting to the argument. I see no way whatever of etting over it.

V. The teats of animals which give suck bear a elation to the mouth of the suckling progeny, particu-arly to the lips and tongue. Here also, as before, is a orrespondency of parts, which parts subsist in differ-nt individuals.

These are *general* relations, or the relations of parts which are found either in all animals or in large classes and descriptions of animals. *Particular* relations, or the relations which subsist between the particular configuration of one or more parts of certain species of animals, and the particular configuration of one or more other parts of the same animal (which is the sort of relation that is, perhaps, most striking) are such as the following:

I. In the *swan*, the web-foot, the spoon-bill, the long neck, the thick down, the graminivorous stomach, bear all a relation to one another, inasmuch as they all concur in one design, that of supplying the occasions of an aquatic fowl floating upon the surface of shallow pools of water, and seeking its food at the bottom. Begin with any one of these particularities of structure, and observe how the rest follow it. The web-foot qualifies the bird for swimming; the spoon-bill enables it to graze. But how is an animal floating upon the surface of pools of water to graze at the bottom except by the mediation of a long neck? A long neck accordingly is given to it. Again, a warm-blooded animal which was to pass its life upon water, required a defence against the coldness of that element. Such a defence is furnished to the swan in the muff in which its body is wrapped. But all this outward apparatus would have been in vain if the intestinal system had not been suited to the digestion of vegetable substances: I say suited to the digestion of vegetable substances; for it is well known that there are two intestinal systems found in birds: one with a membranous stomach and a gastric juice, capable of dissolving animal substances alone—the other with a crop and izzard calculated for the moistening, bruising, and fterwards digesting, of vegetable aliment.

Or set off with any other distinctive part in the ody of the swan; for instance, with the long neck. 'he long neck, without the web-foot, would have een an encumbrance to the bird; yet there is no ne- essary connection between a long neck and a web- ot. In fact they do not usually go together. How appens it, therefore, that they meet only when a par- cular design demands the aid of both?

II. This mutual relation arising from a subservien- y to a common purpose, is very observable also in the arts of a *mole*. The strong short legs of that animal, e palmated feet, armed with sharp nails, the pig-like ose, the teeth, the velvet coat, the small external ear, e sagacious smell, the sunk protected eye, all con- uce to the utilities or to the safety of its under-ground fe. It is a special purpose, especially consulted through- ut. The form of the feet fixes the character of the ani- al. They are so many shovels; they determine its tion to that of rooting in the ground; and every ing about its body agrees with its destination. The ylindrical figure of the mole, as well as the compact- ess of its form, arising from the terseness of its limbs, oportionably lessens its labor; because, according to s bulk, it thereby requires the least possible quantity earth to be removed for its progress. It has nearly e same structure of the face and jaws as a swine, nd the same office for them. The nose is sharp, slen- er, tendinous, strong, with a pair of nerves going own to the end of it. The plush covering which, by the smoothness, closeness, and polish of the short pile that compose it, rejects the adhesion of almost every species of earth, defends the animal from cold and wet, and from the impediment which it would experience by the mould sticking to its body. From soils of all kinds the little pioneer comes forth bright and clean. Inhabiting dirt, it is of all animals the neatest.

But what I have always most admired in the mole is its *eyes.* This animal occasionally visiting the surface, and wanting, for its safety and direction, to be informed when it does so, or when it approaches it, a perception of light was necessary. I do not know that the clearness of sight depends at all upon the size of the organ. What is gained by the largeness or prominence of the globe of the eye, is width in the field of vision. Such a capacity would be of no use to an animal which was to seek its food in the dark. The mole did not want to look about it; nor would a large advanced eye have been easily defended from the annoyance to which the life of the animal must constantly expose it. How indeed was the mole, working its way under ground, to guard its eyes at all? In order to meet this difficulty, the eyes are made scarcely larger than the head of a corking-pin; and these minute globules are sunk so deeply in the skull, and lie so sheltered within the velvet of its covering, as that any contraction of what may be called the eye-brows, not only closes up the apertures which lead to the eyes, but presents a cushion, as it were, to any sharp or protruding substance which might push against them. This aperture, even in its ordinary state, is like a pin hole in a piece of velvet, scarcely pervious to loose particles of earth.

Observe, then, in this structure that which we call relation. There is no natural connection between a small sunk eye and a shovel palmated foot. Palmated feet might have been joined with goggle eyes; or small eyes might have been joined with feet of any other form. What was it therefore which brought them together in the mole? That which brought together the barrel, the chain, and the fusee in a watch —design; and design in both cases inferred, from the relation which the parts bear to one another in the prosecution of a common purpose. As hath already been observed, there are different ways of stating the relation, according as we sat out from a different part. In the instance before us, we may either consider the shape of the feet, as qualifying the animal for that mode of life and inhabitation to which the structure of the eye confines it; or we may consider the structure of the eye as the only one which would have suited with the action to which the feet are adapted. The relation is manifest, whichever of the parts related we place first in the order of our consideration. In a word, the feet of the mole are made for digging; the neck, nose, eyes, ears, and skin are peculiarly adapted to an under-ground life; and this is what I call relation.

CHAPTER XVI.

COMPENSATION.

Compensation is a species of relation. It is relation when the *defects* of one part, or of one organ, are supplied by the structure of another part, or of another organ. Thus—

I. The short unbending neck of the *elephant* is compensated by the length and flexibility of his *proboscis*. He could not have reached the ground without it; or, if it be supposed that he might have fed upon the fruit, leaves, or branches of trees, how was he to drink? Should it be asked, why is the elephant's neck so short? it may be answered, that the weight of a head so heavy could not have been supported at the end of a longer lever. To a form, therefore, in some respects necessary, but in some respects also inadequate to the occasion of the animal, a supplement is added which exactly makes up the deficiency under which he labored.

If it be suggested that this proboscis may have been produced, in a long course of generations, by the constant endeavor of the elephant to thrust out its nose, (which is the general hypothesis by which it has lately been attempted to account for the forms of animated nature,) I would ask, How was the animal to subsist in the mean time—during the process—*until* this prolongation of snout were completed? What was to become of the individual whilst the species was perfecting?

Our business at present is, simply to point out the relation which this organ bears to the peculiar figure of the animal to which it belongs. And herein all things correspond. The necessity of the elephant's proboscis arises from the shortness of his neck: the shortness of the neck is rendered necessary by the weight of the head. Were we to enter into an examination of the structure and anatomy of the proboscis itself, we should see in it one of the most curious of all examples of animal mechanism. The disposition of the ringlets and fibres, for the purpose, first, of forming a long cartilaginous pipe; secondly, of contracting and lengthening that pipe; thirdly, of turning it in every direction at the will of the animal; with the superaddition at the end of a fleshy production, of about the length and thickness of a finger, and performing the office of a finger, so as to pick up a straw from the ground. These properties of the same organ, taken together, exhibit a specimen, not only of design, (which is attested by the advantage,) but of consummate art, and as I may say, of elaborate preparation, in accomplishing that design.

II. The hook in the wing of a *bat* is strictly a mechanical, and, also, a *compensating* contrivance. At the angle of its wing there is a bent claw, exactly in the form of a hook, by which the bat attaches itself to the sides of rocks, caves, and buildings, laying hold of crevices, joinings, chinks and roughnesses. It hooks itself by this claw; remains suspended by this hold;

takes its flight from this position: which operations compensate for the decrepitude of its legs and feet. Without her hook the bat would be the most helpless of all animals. She can neither run upon her feet, nor raise herself from the ground. These inabilities are made up to her by the contrivance in her wing; and in placing a claw on that part, the Creator has deviated from the analogy observed in winged animals. A singular defect required a singular substitute.

III. The *crane* kind are to live and seek their food amongst the waters; yet having no web-foot, are incapable of swimming. To make up this deficiency they are furnished with long legs for wading, or long bills for groping, or usually with both. This is *compensation*. But I think the true reflection upon the present instance is, how every part of nature is tenanted by appropriate inhabitants. Not only is the surface of the deep waters peopled by numerous tribes of birds that swim, but marshes and shallow pools are furnished with hardly less numerous tribes of birds that wade.

IV. The common *parrot* has, in the structure of its beak, both an inconveniency and a *compensation* for it. When I speak of an inconveniency I have a view to a dilemma which frequently occurs in the works of nature—viz. that the peculiarity of structure by which an organ is made to answer one purpose necessarily unfits it for some other purpose. This is the case before us. The upper bill of the parrot is so much hooked, and so much overlaps the lower, that if, as in other birds, the lower chap alone had motion, the bird could scarcely gape wide enough to receive its food: yet this hook and overlapping of the bill could not be spared, for it forms the very instrument by which the bird climbs,—to say nothing of the use which it makes of it in breaking nuts and the hard substances upon which it feeds. How, therefore, has nature provided for the opening of this occluded mouth? By making the upper chap movable, as well as the lower. In most birds, the upper chap is connected, and makes but one piece with the skull; but in the parrot the upper chap is joined to the bone of the head by a strong membrane placed on each side of it, which lifts and depresses it at pleasure.*

V. The *spider's web* is a *compensating* contrivance The spider lives upon flies, without wings to pursue them,—a case, one would have thought, of great difficulty, yet provided for, and provided for by a resource which no stratagem, no effort of the animal, could have produced, had not both its external and internal structure been specifically adapted to the operation.

VI. In many species of insects the eye is fixed, and consequently without the power of turning the pupil to the object. The great defect is, however, perfectly *compensated*, and by a mechanism which we should not suspect. The eye is a multiplying-glass with a lens looking in every direction and catching every object. By which means, although the orb of the eye be stationary, the field of vision is as ample as that of other animals, and is commanded on every side. When this lattice-work was first observed, the

* Goldsmith's Nat. Hist. vol. v. p. 274.

multiplicity and minuteness of the surfaces must have added to the surprise of the discovery. Adams tells us that fourteen hundred of these reticulations have been counted in the two eyes of a drone-bee.

In other cases the *compensation* is effected by the number and position of the eyes themselves. The spider has eight eyes, mounted upon different parts of the head; two in front, two in the top of the head, two on each side. These eyes are without motion, but, by their situation, suited to comprehend every view which the wants or safety of the animal rendered it necessary for it to take.

VII. The Memoirs for the Natural History of Animals, published by the French Academy, A. D. 1687, furnish us with some curious particulars in the eye of a cameleon. Instead of two eye-lids, it is covered by an eyelid with a hole in it. This singular structure appears to be *compensatory*, and to answer to some other singularities in the shape of the animal. The neck of the cameleon is inflexible. To make up for this, the eye is so prominent as that more than half of the ball stands out of the head, by means of which extraordinary projection the pupil of the eye can be carried by the muscles in every direction, and is capable of being pointed towards every object. But then, so unusual an exposure of the globe of the eye requires for its lubricity and defence a more than ordinary protection of eyelid, as well as a more than ordinary supply of moisture; yet the motion of the eyelid, formed according to the common construction, would be impeded, as it should seem, by the convexity of the organ.

The aperture in the lid meets this difficulty. It enables the animal to keep the principal part of the surface of the eye under cover, and to preserve it in a lue state of humidity without shutting out the light, or without performing every moment a nictitation which it is probable would be more laborious to this animal than to others.

VIII. In another animal, and in another part of the animal economy, the same Memoirs describe a most emarkable *substitution*. The reader will remember what we have already observed concerning the *intesinal* canal—that its length, so many times exceeding hat of the body, promotes the extraction of the chyle rom the aliment by giving room for the lacteal vessels o act upon it through a greater space. This long inestine, wherever it occurs, is in other animals disposed n the abdomen from side to side in returning folds. But in the animal now under our notice the matter is managed otherwise. The same intention is mechanially effectuated but by a mechanism of a different ind. The animal of which I speak is an amphibius quadruped, which our authors call the alopecias r sea-fox. The intestine is straight from one end o the other; but in this straight and consequently hort intestine is a winding, corkscrew, spiral passage, hrough which the food, not without several circumolutions, and in fact by a long route, is conducted to s exit. Here the shortness of the gut is *compensated* y the obliquity of the perforation.

IX. But the works of the Deity are known by exedients. Where we should look for an absolute destitution—where we can reckon up nothing but want —some contrivance always comes in to supply the pri vation. A *snail*, without wings, feet, or thread, climb up the stalks of plants by the sole aid of a vicid hu mor discharged from her skin. She adheres to th stems, leaves and fruits of plants by means of a stick ing-plaster. A *mussel*, which might seem by its help lessness to lie at the mercy of every wave that wen over it, has the singular power of spinning strong ten dinous threads by which she moors her shell to rock and timbers. A *cockle*, on the contrary, by means c its stiff tongue, works for itself a shelter in the sand The provisions of nature extend to cases the most des perate. A *lobster* has in its constitution a difficult so great that one could hardly conjecture beforehan how nature would dispose of it. In most animals th skin grows with their growth. If, instead of a sof skin, there be a shell, still it admits a gradual enlarge ment. If the shell, as in the tortoise, consist of severa pieces, the accession of substance is made at the su tures. Bivalve shells grow bigger by receiving an ac cretion at their edge; it is the same with spiral shell at their mouth. The simplicity of their form admit of this. But the lobster's shell being applied to th limbs of the body, as well as to the body itself, allow not of either of the modes of growth which are ob served to take place in other shells. Its hardness re sists expansion; and its complexity renders it incapa ble of increasing its size by addition of substance to it edge. How then was the growth of the lobster to b provided for? Was room to be made for it in the ol ell, or was it successively fitted with new ones? If change of shell became necessary, how was the lob er to extricate himself from his present confinement? w was he to uncase his buckler, or draw his legs t of his boots? The process which fishermen have served to take place is as follows: At certain seasons e shell of the lobster grows soft; the animal swells body; the seams open, and the claws burst at the nts. When the shell has thus become loose upon the dy, the animal makes a second effort, and by a mulous spasmodic motion casts it off. In this state e liberated but defenceless fish retires into holes in e rock. The released body now suddenly pushes growth. In about eight-and-forty hours a fresh con- tion of humour upon the surface, *i. e.* a new shell, formed, adapted in every part to the increased di- ensions of the animal. This wonderful mutation is peated every year.

If there be imputed defects without compensation, I ould suspect that they were defects only in appear- ce. Thus, the body of the *sloth* has often been re- oached for the slowness of its motions, which has en attributed to an imperfection in the formation of limbs. But it ought to be observed that it is this wness which alone suspends the voracity of the ani- al. He fasts during his migration from one tree to other: and this fast may be necessary for the relief his over-charged vessels, as well as to allow time the concoction of the mass of coarse and hard food hich he has taken into his stomach. The tardiness his pace seems to have reference to the capacity of

his organs, and to his propensities with respect to fo
—*i. e.* is calculated to counteract the effects of
pletion.

Or there may be cases in which a defect is artifici
and compensated by the very cause which produc
it. Thus the *sheep*, in the domesticated state in whi
we see it, is destitute of the ordinary means of defen
or escape—is incapable either of resistance or flig
But this is not so with the wild animal. The natu
sheep is swift and active; and, if it lose these qualit
when it comes under the subjection of man, the lo
is compensated by his protection. Perhaps there is
species of quadruped whatever which suffers so lit
as this does from the depredation of animals of pre

For the sake of making our meaning better unde
stood, we have considered this business of compens
tion under certain *particularities* of constitution
which it appears to be most conspicuous. This vie
of the subject necessarily limits the instances to sing
species of animals. But there are compensations, pe
haps not less certain, which extend over large class
and to large portions of living nature.

I. In quadrupeds the deficiency of teeth is usual
compensated by the faculty of rumination. The shee
deer, and ox tribe are without fore-teeth in the upp
jaw. These ruminate. The horse and ass are furnis
ed with teeth in the upper jaw, and do not rumina
In the former class, the grass and hay descend in
the stomach nearly in the state in which they a
cropped from the pasture or gathered from the bund
In the stomach they are softened by the gastric juic

vhich in these animals is unusually copious: thus oftened and rendered tender, they are returned a se- ond time to the action of the mouth, where the grind- ıg teeth complete at their leisure the trituration which ; necessary, but which was before left imperfect: I say ıe trituration which is necessary; for it appears from xperiments that the gastric fluid of sheep, for example, as no effect in digesting plants unless they have been reviously masticated: that it only produces a slight ıaceration, nearly as common water would do in a ke degree of heat; but that when once vegetables re reduced to pieces by mastication, the fluid then ex- rts upon them its specific operation. Its first effect is ɔ soften them, and to destroy their natural consis- ency: it then goes on to dissolve them, not sparing even ıe toughest parts, such as the nerves of the leaves.*

I think it very probable that the gratification also f the animal is renewed and prolonged by this faculty. heep, deer and oxen appear to be in a state of enjoy- ıent whilst they are chewing the cud: it is then, per- aps, that they best relish their food.

II. In birds the *compensation* is still more striking. They have no teeth at all. What have they then to ıake up for this severe want? I speak of granivorous nd herbivorous birds: such as common fowls, turkeys, ucks, geese, pigeons, &c.; for it is concerning these lone that the question need be asked. All these are ırnished with a peculiar and most powerful muscle, ılled the *gizzard;* the inner coat of which is fitted

* Spall. Dis. iii. sect. cxl.

up with rough plaits, which, by a strong fricti against one another, break and grind the hard alime as effectually, and by the same mechanical action, a coffee-mill would do. It has been proved by t most correct experiments that the gastric juice of the birds will not operate upon the *entire* grain: not ev when softened by water or macerated in the cro Therefore, without a grinding machine within its bod without the trituration of the gizzard, a chicken wou have starved upon a heap of corn. Yet, why shou a bill and a gizzard go together? why should a g zard never be found where there are teeth?

Nor does the gizzard belong to birds as such. gizzard is not found in birds of prey: *their* food quires not to be ground down in a mill. The compe satory contrivance goes no further than the necessit In both classes of birds, however, the digestive org within the body bears a strict and mechanical relati to the external instruments for procuring food. T soft membranous stomach accompanies a hooke notched beak; short muscular legs; strong, sha crooked talons;—the cartilaginous stomach atten that conformation of bill and toes which restrains t bird to the picking of seeds or the cropping of plan

III. But to proceed with our *compensations*. A ve numerous and comprehensive tribe of terrestrial a mals are entirely without feet—yet locomotive, and a very considerable degree swift in their motion. Ho is the *want of feet* compensated? It is done by t disposition of the muscles and fibres of the trunk. consequence of the just collocation and by means e joint action of longitudinal and annular fibres—at is to say, of strings and rings—the body and train reptiles are capable of being reciprocally shortened d lengthened, drawn up and stretched out. The sult of this action is a progressive, and in some cases rapid movement of the whole body, in any direction which the will of the animal determines it. The eanest creature is a collection of wonders. The play the rings in an *earth-worm*, as it crawls, the undulary motion propagated along the body, the beards or ickles with which the annuli are armed, and which e animal can either shut up close to its body, or let it to lay hold of the roughness of the surface upon hich it creeps, and the power arising from all these changing its place and position, afford, when comared with the provisions for motion in other animals, roofs of new and appropriate mechanism. Suppose at we had never seen an animal move upon the round without feet, and that the problem was: Musılar action, *i. e.* reciprocal contraction and relaxation eing given, to describe how such an animal might be onstructed capable of voluntarily changing place. omething, perhaps, like the organization of reptiles ight have been hit upon by the ingenuity of an rtist; or might have been exhibited in an automaton, y the combination of springs, spiral wires, and ringts: but to the solution of the problem would not be enied, surely, the praise of invention and of successıl thought: least of all could it ever be questioned hether intelligence had been employed about it r not.

CHAPTER XVII.

THE RELATION OF ANIMATED BODIES TO INA MATE NATURE.

We have already considered *relation*, and und different views; but it was the relation of parts parts, of the parts of an animal to other parts of t same animal, or of another individual of the sa species.

But the bodies of animals hold, in their constituti and properties, a close and important relation to natu altogether external to their own: to inanimate su stances, and to the specific qualities of these; e. *they hold a strict relation to the* ELEMENTS *by whi they are surrounded.*

I. Can it be doubted, whether the *wings of bir* bear a relation to air, and the *fins of fish* to wate They are instruments of motion severally suited the properties of the medium in which the motion to be performed; which properties are different. W not this difference contemplated when the instrumen were differently constituted?

II. The structure of the animal *ear* depends for i use not simply upon being surrounded by a fluid, b upon the specific nature of that fluid. Every flu would not serve: its particles must repel one anothe it must form an elastic medium: for it is by the su cessive pulses of *such* a medium that the undulatio excited by the surrounding body are carried to t

·gan; that a communication is formed between the ɔject and the sense; which must be done before the ternal machinery of the ear, subtile as it is, can act all.

III. The *organs* of voice and respiration are, no ss than the ear, indebted, for the success of their ɔeration, to the peculiar qualities of the fluid in which e animal is immersed. They, therefore, as well as e ear, are constituted upon the supposition of such a uid, *i. e.* of a fluid with such particular properties, ing always present. Change the properties of the uid, and the organ cannot act; change the organ, ıd the properties of the fluid would be lost. The ucture, therefore, of our organs, and the properties our atmosphere, are made for one another. Nor es it alter the relation, whether you allege the organ be made, for the element, (which seems the most tural way of considering it,) or the elements as pre-red for the organ.

IV. But there is another fluid with which we have do; with properties of its own; with laws of acting, d of being acted upon, totally different from those air and water: and that is *light*. To this new, is singular element—to qualities perfectly peculiar, rfectly distinct and remote from the qualities of any ıer substance with which we are acquainted—an gan is adapted, an instrument is correctly adjusted, t less peculiar amongst the parts of the body, not s singular in its form and in the substance of which is composed, not less remote from the materials, the ɔdel, and the analogy of any part of the animal frame, than the element to which it relates is speci amidst the substances with which we converse. If th does not prove appropriation, I desire to know wh would prove it.

Yet the element of light and the organ of visio however related in their office and use, have no co nection whatever in their original. The action of ra of light upon the surfaces of animals has no tenden to breed eyes in their heads. The sun might shi for ever upon living bodies without the smallest a proach towards producing the sense of sight. On t other hand also, the animal eye does *not* generate emit light.

V. Throughout the universe there is a wonderf *proportioning* of one thing to another. The size animals, the human animal especially, when consider with respect to other animals, or to the plants whi grow around him, is such as a regard to his conven ency would have pointed out. A giant or a pigm could not have milked goats, reaped corn, or mow grass; we may add could not have rode a hors trained a vine, shorn a sheep, with the same bodi ease we can do, if at all. A pigmy would have be lost amongst rushes, or carried off by birds of prey.

It may be mentioned, likewise, that the model a the materials of the human body being what they a a much greater bulk would have broken down by own weight. The persons of men who much exce the ordinary stature betray this tendency.

VI. Again, (and which includes a vast variety of p ticulars, and those of the greatest importance,) h lose is the *suitableness* of the earth and sea to theii everal inhabitants; and of these inhabitants to the laces of their appointed residence!

Take the *earth* as it is; and consider the corres-ondency of the powers of its inhabitants with the pro-erties and condition of the soil which they tread. 'ake the inhabitants as they are; and consider the ubstances which the earth yields for their use. They an scratch its surface, and its surface supplies all hich they want. This is the length of their faculties; nd such is the constitution of the globe, and their wn, that this is sufficient for all their occasions.

When we pass from the earth to the *sea*, from land water, we pass through a great change: but an ade-uate change accompanies us of animal forms and inctions, of animal capacities and wants; so that *cor-espondency* remains. The earth in its nature is very ifferent from the sea, and the sea from the earth, but ne accords with its inhabitants as exactly as the ther.

VII. The last relation of this kind which I shall iention is that of *sleep* to *night*; and it appears to me be a relation which was expressly intended. Two oints are manifest; first, that the animal frame requires eep; secondly, that night brings with it a silence and cessation of activity which allows of sleep being iken without interruption and without loss. Animal xistence is made up of action and slumber; nature as provided a season for each. An animal which ood not in need of rest would always live in daylight. n animal which, though made for action, and de-lighting in action, must have its strength repaired by sleep, meets, by its constitution, the returns of day and night. In the human species, for instance, were th bustle, the labor, the motion of life upheld by the con stant presence of light, sleep could not be enjoyed with out being disturbed by noise, and without expense o that time which the eagerness of private interest woul not contentedly resign. It is happy, therefore, for thi part of the creation, I mean that it is conformable t the frame and wants of their constitution, that natur by the very disposition of her elements, has com manded, as it were, and imposed upon them, at mode rate intervals, a general intermission of their toil their occupations, and pursuits.

But it is not for man, either solely or principall that night is made. Inferior but less perverted na tures taste its solace, and expect its return with great exactness and advantage than he does. I have ofte observed, and never observed but to admire, the sati faction, no less than the regularity, with which th greatest part of the irrational world yield to this so necessity, this grateful vicissitude: how comfortabl the birds of the air, for example, address themselv to the repose of the evening, with what alertness the resume the activity of the day.

Nor does it disturb our argument to confess th certain species of animals are in motion during th night, and at rest in the day. With respect even them, it is still true that there is a change of conditio in the animal, and an external change correspondin with it. There is still the relation, though inverte

Γhe fact is, that the repose of other animals sets these ıt liberty, and invites them to their food or their sport.

If the relation of *sleep* to *night*, and, in some in-stances, its converse, be real, we cannot reflect without ımazement upon the extent to which it carries us. Day and night are things close to us; the change ıpplies immediately to our sensations; of all the phe-ıomena of nature, it is the most obvious and the most familiar to our experience; but, in its cause, it belongs o the great motions which are passing in the heavens. Whilst the earth glides round her axle, she ministers o the alternate necessities of the animals dwelling ıpon her surface, at the same time that she obeys the nfluence of those attractions which regulate the order of many thousand worlds. The relation, therefore, of sleep to night is the relation of the inhabitants of the earth to the rotation of their globe; probably it is nore, it is a relation to the system of which that globe s a part; and, still further, to the congregation of sys-ems of which theirs is only one. If this account be rue, it connects the meanest individual with the uni-verse itself,—a chicken roosting upon its perch with he spheres revolving in the firmament.

VIII. But if any one object to our representation, hat the succession of day and night, or the rotation of the earth upon which it depends, is not resolvable nto central attraction, we will refer him to that which ertainly is,—to the change of the seasons. Now the onstitution of animals susceptible of torpor bears a elation to winter similar to that which sleep bears to night. Against not only the cold, but the want of food, which the approach of winter induces, the Preserver of the world has provided in many animals by migration, in many others by torpor. As one example out of a thousand, the bat, if it did not sleep through the winter, must have starved; as the moths and flying insects upon which it feeds disappear. But the transition from summer to winter carries us into the very midst of physical astronomy, that is to say, into the midst of those laws which govern the solar system at least, and probably all the heavenly bodies.

CHAPTER XVIII.

INSTINCTS.

The order may not be very obvious by which I place *instincts* next to relations. But I consider them as a species of relation. They contribute, along with the animal organization, to a joint effect, in which view they are related to that organization. In many cases they refer from one animal to another animal; and, when this is the case, become strictly relations in a second point of view.

An INSTINCT is a propensity prior to experience and independent of instruction. We contend that it is by *instinct* that the sexes of animals seek each other; that animals cherish their offspring; that the young uadruped is directed to the teat of its dam; that irds build their nests and brood with so much patience pon their eggs; that insects which do not sit upon ıeir eggs deposit them in those particular situations ı which the young when hatched find their appro-:iate food: that it is instinct which carries the salmon, ıd some other fish, out of the sea into rivers, for the ırpose of shedding their spawn in fresh water.

We may select out of *this* catalogue the incubation ' eggs. I entertain no doubt but that a couple of ıarrows hatched in an oven, and kept separate from .e rest of their species, would proceed as other spar-ws do in every office which related to the production ıd preservation of their brood. Assuming this fact, .e thing is inexplicable upon any other hypothesis .an that of an instinct impressed upon the constitu-on of the animal. For, first, what should induce the male bird to prepare a nest before she lays her eggs? is in vain to suppose her to be possessed of the fa-ılty of reasoning; for no reasoning will reach the se. The fullness or distension which she might el in a particular part of the body, from the growth ıd solidity of the egg within her, could not possibly form her that she was about to produce something hich, when produced, was to be preserved and taken re of. Prior to experience there was nothing to lead this inference, or to this suspicion. The analogy as *all* against it; for, in every other instance, what sued from the body was cast out and rejected.

But, secondly, let us suppose the egg to be produced to day; how should birds know that their eggs contain their young? There is nothing either in th aspect or in the internal composition of an egg whic could lead even the most daring imagination to con jecture that it was hereafter to turn out from under it shell a living perfect bird. The form of the egg bear not the rudiments of a resemblance to that of the bird Inspecting its contents, we find still less reason, if pos sible, to look for the result which actually takes place If we should go so far as, from the appearance of orde and distinction in the disposition of the liquid substan ces which we noticed in the egg, to guess that it migh be designed for the abode and nutriment of an anima (which would be a very bold hypothesis,) we shoul expect a tadpole dabbling in the slime, much mor than a dry, winged, feathered creature, a compound o parts and properties impossible to be used in a state o confinement in the egg, and bearing no conceivabl relation, either in quality or material, to any thing ob served in it. From the white of an egg, would an one look for the feather of a goldfinch? or expec from a simple uniform mucilage the most complicate of all machines, the most diversified of all collection of substances? Nor would the process of incubatio for some time at least, lead us to suspect the even Who that saw red streaks shooting in the fine mem brane which divides the white from the yolk, woul suppose that these were about to become bones an limbs? Who that espied two discolored points firs making their appearance in the cicatrix, would hav had the courage to predict that these points were t grow into the heart and head of a bird? It is difficu strip the mind of its experience. It is difficult to esuscitate surprise when familiarity has once laid the entiment asleep. But could we forget all that we now, and which our sparrows never knew, about viparous generation—could we divest ourselves of very information but what we derived from reasoning pon the appearances or quality discovered in the obcts presented to us—I am convinced that Harlequin oming out of an egg upon the stage is not more asnishing to a child than the hatching of a chicken oth would be, and ought to be, to a philosopher.

But admit the sparrow by some means to know that ithin that egg was concealed the principle of a future ird: from what chemist was she to learn that *warmth* as necessary to bring it to maturity, or that the deree of warmth imparted by the temperature of her wn body was the degree required?

To suppose, therefore, that the female bird acts in is process from a sagacity and reason of her own, is suppose her to arrive at conclusions which there are o premises to justify. If our sparrow, sitting upon her ggs, expect young sparrows to come out of them, she rms, I will venture to say, a wild and extravagant xpectation, in opposition to present appearances and probability. She must have penetrated into the der of nature further than any faculties of ours will arry us; and it hath been well observed, that this eep sagacity, if it be sagacity, subsists in conjunction ith great stupidity, even in relation to the same subct. "A chemical operation," says Addison, "could ot be followed with greater art or diligence than is seen in hatching a chicken; yet is the process carrie on without the least glimmering of thought or com mon sense. The hen will mistake a piece of chalk fo an egg—is insensible of the increase or diminution c their number—does not distinguish between her ow and those of another species—is frightened when he supposititious breed of ducklings take the water.

But it will be said, that what reason could not do fo the bird, observation, or instruction, or tradition migh Now if it be true that a couple of sparrows, brougl up from the first in a state of separation from all othe birds, would build their nest, and brood upon thei eggs, then there is an end of this solution. What ca be the traditionary knowledge of a chicken hatched i an oven?

Of young birds taken in their nests, a few specie breed when kept in cages; and they which do so, buil their nests nearly in the same manner as in the wil state, and sit upon their eggs. This is sufficient t prove an instinct without having recourse to experi ments upon birds hatched by artificial heat, and de prived from their birth of all communication with thei species; for we can hardly bring ourselves to believ that the parent bird informed her unfledged pupil c the history of her gestation, her timely preparation c a nest, her exclusion of the eggs, her long incubatior and of the joyful eruption at last of her expected of spring: all which the bird in the cage must have lear in her infancy if we resolve her conduct into *institutior*

Unless we will rather suppose that she remembe her own escape from the egg—had attentively obser ed the conformation of the nest in which she was nurtured—and had treasured up her remarks for future imitation; which is not only extremely improbable, (for who that sees a brood of callow birds in their nest can believe that they are taking a plan of their habitation?) but leaves unaccounted for one principal part of the difficulty, "the preparation of the nest before the laying of the egg." This she could not gain from observation in her infancy.

It is remarkable also, that the hen sits upon eggs which she has laid without any communication with the male, and which are therefore necessarily unfruitful. That secret she is not let into. Yet if incubation had been a subject of instruction or of tradition, it should seem that this distinction would have formed part of the lesson; whereas the instinct of nature is calculated for a state of nature—the exception here alluded to taking place chiefly, if not solely, amongst domesticated fowls, in which nature is forced out of her course.

There is another case of oviparous economy, which is still less likely to be the effect of education than it is even in birds, namely, that of *moths* and *butterflies*, which deposit their eggs in the precise substance—that of a cabbage, for example—from which, not the butterfly herself, but the caterpillar which is to issue from her egg, draws its appropriate food. The butterfly cannot taste the cabbage: cabbage is no food for her; yet in the cabbage, not by chance, but studiously and electively, she lays her eggs. There are, amongst many other kinds, the willow-caterpillar and the cabbage-caterpillar; but we never find upon a willow the caterpillar which eats the cabbage, nor the converse. This choice, as appears to me, cannot in the butterfly proceed from instruction. She had no teacher in her caterpillar state. She never knew her parent. I do not see, therefore, how knowledge acquired by experience, if it ever were such, could be transmitted from one generation to another. There is no opportunity either for instruction or imitation. The parent race is gone before the new brood is hatched. And if it be original reasoning in the butterfly, it is profound reasoning indeed. She must remember her caterpillar state, its tastes and habits, of which memory she shows no signs whatever. She must conclude from analogy, (for here her recollection cannot serve her,) that the little round body which drops from her abdomen will at a future period produce a living creature, not like herself, but like the caterpillar which she remembers herself once to have been. Under the influence of these reflections, she goes about to make provision for an order of things which she concludes will some time or other take place. And it is to be observed, that not a few out of many, but that all butterflies argue thus; all draw this conclusion; all act upon it.

But suppose the address, and the selection, and the plan, which we perceive in the preparations which many irrational animals make for their young, to be traced to some probable origin, still there is left to be accounted for that which is the source and foundation of these phenomena, that which sets the whole at work, the $\sigma\tau o\rho\gamma\eta$, the parental affection, which I contend to be inexplicable upon any other hypothesis han that of instinct.

For we shall hardly, I imagine, in brutes, refer their conduct towards their offspring to a sense of duty or of lecency, a care of reputation, a compliance with public manners, with public laws, or with rules of life uilt upon a long experience of their utility. And all ttempts to account for the parental affection from ssociation, I think, fail. With what is it associated? Iost immediately with the throes of parturition, that s, with pain, and terror, and disease. The more remote, but not less strong association, that which depends upon analogy, is all against it. Every thing lse which proceeds from the body is cast away and ejected. In birds is it the egg which the hen loves? r is it the expectation which she cherishes of a future rogeny that keeps her upon her nest? What cause as she to expect delight from her progeny? Can any ational answer be given to the question, why, prior to xperience, the brooding hen should look for pleasure rom her chickens? It does not, I think, appear that ne cuckoo ever knows her young; yet, in her way, he is as careful in making provision for them as any ther bird. She does not leave her egg in every hole.

The salmon suffers no surmountable obstacle to opose her progress up the stream of fresh rivers. And vhat does she do there? She sheds a spawn, which he immediately quits in order to return to the sea; nd this issue of her body she never afterwards recogises in any shape whatever. Where shall we find a

motive for her efforts and her perseverance? Shal
we seek it in argumentation or in instinct? The vio
let crab of Jamaica performs a fatiguing march o
some months' continuance from the mountains to th
sea-side. When she reaches the coast she casts he
spawn into the open sea, and sets out upon her re
turn home.

Moths and butterflies, as hath already been observed
seek out for their eggs those precise situations and sub
stances in which the offspring caterpillar will find it
appropriate food. That dear caterpillar the paren
butterfly must never see. There are no experiment
to prove that she would retain any knowledge of it i
she did. How shall we account for her conduct?
do not mean for her art and judgment in selecting an
securing a maintenance for her young, but for the im-
pulse upon which she acts. What should induce he
to exert any art, or judgment, or choice, about th
matter? The undisclosed grub, the animal which sh
is destined not to know, can hardly be the object of a
particular affection, if we deny the influence of instinct
There is nothing therefore left to her, but that of which
her nature seems incapable, an abstract anxiety for th
general preservation of the species—a kind of patriot
ism—a solicitude lest the butterfly race should ceas
from the creation.

Lastly, the principle of association will not explai
the discontinuance of the affection when the youn
animal is grown up. Association operating in its usua
way would rather produce a contrary effect. The ob
ject would become more necessary by habits of society

whereas birds and beasts, after a certain time, banish their offspring, disown their acquaintance, seem to have even no knowledge of the objects which so lately engrossed the attention of their minds and occupied the industry and labor of their bodies. This change, in different animals, takes place at different distances of time from the birth; but the time always corresponds with the ability of the young animal to maintain itself, never anticipates it. In the sparrow tribe, when it is perceived that the young brood can fly and shift for themselves, then the parents forsake them for ever; and though they continue to live together, pay them no more attention than they do to other birds in the same flock.* I believe the same thing is true of all gregarious quadrupeds. In this part of the case the variety of resources, expedients, and materials which animals of the same species are said to have recourse to under different circumstances, and when differently supplied, makes nothing against the doctrine of instincts. The thing which we want to account for is the propensity. The propensity being there, it is probable enough that it may put the animal upon different actions according to different exigencies. And this adaptation of resources may look like the effect of art and consideration rather than of instinct; but still the propensity is instinctive. For instance, suppose what is related of the woodpecker to be true, that in Europe she deposits her eggs in cavities she scoops out in the trunks of soft or decayed trees, and in which

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* Goldsmith's Natural History, vol. iv. p. 244.

cavities the eggs lie concealed from the eye, and in some sort safe from the hand of man, but that in the forests of Guinea and the Brazils, which man seldom frequents, the same bird hangs her nest on the twigs of tall trees, thereby placing them out of the reach of *monkeys* and *snakes*—*i. e.* that in each situation she prepares against the danger which she has most occasion to apprehend. Suppose, I say, this to be true, and to be alleged, on the part of the bird that builds these nests, as evidence of a reasoning and distinguishing precaution: still the question returns, whence the propensity to build at all?

Nor does parental affection accompany generation by any universal law of animal organization, if such a thing were intelligible. Some animals cherish their progeny with the most ardent fondness and most assiduous attention; others entirely neglect them; and this distinction always meets the constitution of the young animal with respect to its wants and capacities. In many, the parental care extends to the young animal; in others, as in all oviparous fish, it is confined to the egg, and even as to that, to the disposal of it in its proper element. Also, as there is generation without parental affection, so is there parental instinct, or what exactly resembles it, without generation. In the bee tribe, the grub is nurtured neither by the father nor the mother, but by the neutral bee. Probably the case is the same with ants.

I am not ignorant of the theory which resolves instinct into sensation, which asserts that what appears to have a view and relation to the future, is the esult only of the present disposition of the animal's body, and of pleasure or pain experienced *at the time.* Thus the incubation of eggs is accounted for by the pleasure which the bird is supposed to receive from he pressure of the smooth convex surface of the shells against the abdomen, or by the relief which the mild emperature of the egg may afford to the heat of the ower part of the body, which is observed at this time to be increased beyond its usual state. This present gratification is the only motive with the hen for sitting upon her nest; the hatching of the chickens is, with respect to her, an accidental consequence. The affection of viviparous animals for their young is in like manner solved by the relief, and perhaps the pleasure, which they perceive from giving suck. The young animal's seeking, n so many instances, the teat of its dam, is explained from its sense of smell, which is attracted by the odor of milk. The salmon's urging its way up the stream of fresh-water rivers is attributed to some gratification or refreshment which, in this particular state of the fish's body, she receives from the change of element. Now of this theory it may be said,—

First, that of the cases which require solution, there are few to which it can be applied with tolerable probability; that there are none to which it can be applied without strong objections, furnished by the circumstances of the case. The attention of the cow to its calf, and of the ewe to its lamb, appear to be prior to their sucking. The attraction of the calf or lamb to he teat of the dam, is not explained by simply referring it to the sense of smell. What made the scent of milk so agreeable to the lamb that it should follow it up with its nose, or seek with its mouth the place from which it proceeded? No observation, no experience, no argument could teach the new-dropped animal that the substance from which the scent issued was the material of its food. It had never tasted milk before its birth. None of the animals which are not designed for that nourishment ever offer to suck, or to seek out any such food. What is the conclusion, but that the sugescent parts of animals are fitted for their use, and the knowledge of that use put into them?

We assert, secondly, that even as to the cases in which the hypothesis has the fairest claim to consideration, it does not at all lessen the force of the argument for intention and design. The doctrine of instinct is that of appetencies, *superadded* to the constitution of an animal, for the affectuating of a purpose beneficial to the species. The above-stated solution would derive these appetencies from organization; but then this organization is not less specifically, not less precisely, and, therefore, not less evidently adapted to the same ends, than the appetencies themselves would be upon the old hypothesis. In this way of considering the subject, sensation supplies the place of foresight: but this is the effect of contrivance on the part of the Creator. Let it be allowed, for example, that the hen is induced to brood upon her eggs by the enjoyment or relief which, in the heated state of her abdomen, she experiences from the pressure of round smooth surfaces, or from the application of a temperate warmth. How comes this extraordinary heat or

:hing, or call it what you will, which you suppose be the cause of the bird's inclination, to be felt just the time when the inclination itself is wanted: hen it tallies so exactly with the internal constitution the egg, and with the help which that constitution quires in order to bring it to maturity? In my opin-n, this solution, if it be accepted as to the fact, ought increase, rather than otherwise, our admiration of e contrivance. A gardener lighting up his stoves, st when he wants to force his fruit, and when his ees require the heat, gives not a more certain evi-nce of design. So again; when a male and female arrow come together, they do not meet to confer on the expediency of perpetuating their species. ; an abstract proposition, they care not the value of barley-corn whether the species be perpetuated, or t: they follow their sensations, and all those conse-ences ensue, which the wisest counsels could have :tated, which the most solicitous care of futurity, iich the most anxious concern for the sparrow-orld, could have produced. But how do these con-quences ensue? The sensations, and the constitu-n upon which they depend, are as manifestly di-:ted to the purpose which we see fulfilled by them; d the train of intermediate effects as manifestly laid d planned with a view to that purpose: that is to y, design is as completely evinced by the phenome-, as it would be, even if we suppose the operations begin or to be carried on, from what some will al-y to be alone properly called instincts, that is, from sires directed to a future end, and having no ac-

complishment or gratification distinct from the attai
ment of that end.

In a word : I should say to the patrons of this opi
ion, Be it so ; be it that those actions of animals whic
we refer to instinct are not gone about with any vie
to their consequences, but that they are attended
the animal with a present gratification, and are pu
sued for the sake of that gratification alone ; what do
all this prove, but that the *prospection*, which must
somewhere, is not in the animal, but in the Creato

In treating of the parental affection in brutes, o
business lies rather with the origin of the princip
than with the effects and expressions of it. Writ
recount these with pleasure and admiration. The co
duct of many kinds of animals towards their young h
escaped no observer, no historian of nature. "Ho
will they caress them," says Derham, "with their
fectionate notes ; lull and quiet them with their tend
parental voice ; put food into their mouths ; cheri
and keep them warm ; teach them to pick, and e
and gather food for themselves ; and, in a word, p
form the part of so many nurses, deputed by t
Sovereign Lord and Preserver of the world to h
such young and shiftless creatures !" Neither oug
it, under this head, to be forgotten, how much the
stinct *costs* the animal which feels it ; how much
bird, for example, gives up by sitting upon her ne
how repugnant it is to her organization, her hal
and her pleasures. An animal, formed for liberty, s
mits to confinement, in the very season when ev
thing invites her abroad : what is more, an animal

ighting in motion, made for motion, all whose motions re so easy, and so free, hardly a moment, at other imes, at rest, is, for many hours of many days to-ether, fixed to her nest as close as if her limbs were ed down by pins and wires. For my part, I never ee a bird in that situation but I recognise an invisi-le hand detaining the contented prisoner from her elds and groves, for the purpose, as the event proves, ie most worthy of the sacrifice, the most important, ie most beneficial.

But the loss of liberty is not the whole of what the rocreant bird suffers. Harvey tells us that he has ften found the female wasted to skin and bone by tting upon her eggs.

One observation more, and I will dismiss the sub-ct. The *pairing* of birds, and the *non-pairing* of easts, forms a distinction between the two classes, hich shows that the conjugal instinct is modified ith a reference to utility founded on the condition the offspring. In quadrupeds, the young animal aws its nutriment from the body of the dam. The ale parent neither does, nor can contribute any part its sustentation. In the winged race, the young rd is supplied by an importation of food, to procure id bring home which, in a sufficient quantity for the emand of a numerous brood, requires the industry of oth parents. In this difference, we see a reason for e vagrant instinct of the quadruped, and for the ithful love of the feathered mate.

CHAPTER XIX.

OF INSECTS

We are not writing a system of natural histor therefore we have not attended to the classes in which the subjects of that science are distribut What we had to observe concerning different spec of animals, fell easily, for the most part, within t divisions which the course of our argument led us adopt. There remain, however, some remarks up the *insect* tribe which could not properly be int duced under any other of these heads; and whi therefore we have collected into a chapter by the selves.

The structure, and the use of the parts, of insec are less understood than that of quadrupeds and bir not only by reason of their minuteness, or the minu ness of their parts, (for that minuteness we can, some measure, follow with glasses,) but also by reas of the remoteness of their manners and modes of l from those of larger animals. For instance: Insec under all their varieties of form, are endowed w *antennæ*, which is the name given to those long fe ers that rise from each side of the head: but to wh common use or want of the insect kind a provision universal is subservient has not yet been ascertaine and it has not been ascertained, because it admits of a clear, or very probable comparison, with a organs which we possess ourselves, or with the org

f animals which resemble ourselves in their functions
nd faculties, or with which we are better acquainted
an we are with insects. We want a ground of ana-
gy. This difficulty stands in our way as to some
articulars in the insect constitution, which we might
ish to be acquainted with. Nevertheless, there are
any contrivances in the bodies of insects, neither
ubious in their use, nor obscure in their structure,
nd most properly mechanical. These form parts of
ur argument.

I. The *elytra*, or scaly wings of the genus of sca-
bæus or beetle, furnish an example of this kind.
he true wing of the animal is a light, transparent
embrane, finer than the finest gauze, and not unlike
. It is also, when expanded, in proportion to the size
f the animal, very large. In order to protect this de-
cate structure, and, perhaps, also to preserve it in a
ue state of suppleness and humidity, a strong, hard
ase is given to it in the shape of the horny wing
hich we call the elytron. When the animal is at
st, the gauze wings lie folded up under this impene-
able shield. When the beetle prepares for flying, he
ises the integument, and spreads out his thin mem-
ane to the air. And it cannot be observed without
lmiration, what a tissue of cordage, *i. e.* of muscular
ndons, must run in various and complicated, but de-
rminate directions, along this fine surface, in order to
able the animal either to gather it up into a certain
ecise form, whenever it desires to place its wings
der the shelter which nature hath given to them;
to expand again their folds when wanted for action.

In some insects the elytra cover the whole body; others, half; in others only a small part of it; but all, they completely hide and cover the true win Also,

Many or most of the beetle species lodge in holes the earth, environed by hard, rough substances, a have frequently to squeeze their way through narr passages; in which situation, wings so tender, and large, could scarcely have escaped injury, with both a firm covering to defend them, and the capac of collecting themselves up under its protection.

II. Another contrivance, equally mechanical, a equally clear, is the *awl*, or borer, fixed at the tails various species of flies; and with which they pier in some cases, plants; in others, wood; in others, skin and flesh of animals; in others, the coat of chrysalis of insects of a different species from th own; and in others, even lime, mortar, and stone. need not add, that having pierced the substance, th deposit their eggs in the hole. The descriptions wh naturalists give of this organ are such as the follo ing: It is a sharp-pointed instrument, which, in its active state, lies concealed in the extremity of the domen, and which the animal draws out at pleasu for the purpose of making a puncture in the lea stem, or bark of the particular plant which is suite the nourishment of its young. In a sheath, which vides and opens whenever the organ is used, ther inclosed a compact solid, dentated stem, along wh runs a *gutter* or *groove*, by which groove, after penetration is effected, the egg, assisted, in some ca y a peristaltic motion, passes to its destined lodge-ent. In the œstrum or gad-fly, the wimble *draws out* ke the pieces of a spy-glass: the last piece is armed ith three hooks, and is able to bore through the hide f an ox. Can any thing more be necessary to dis-ay the mechanism, than to relate the fact?

III. The *stings* of insects, though for a different ırpose, are, in their structure, not unlike the piercer. he sharpness to which the point in all of them is rought; the temper and firmness of the substance of hich it is composed; the strength of the muscles by hich it is darted out, compared with the smallness ıd weakness of the insect, and with the soft and fri-ɔle texture of the rest of the body,—are properties of ıe sting to be noticed, and not a little to be admired. he sting of a *bee* will pierce through a goat-skin ove. It penetrates the human flesh more readily an the finest point of a needle. The *action* of the ing affords an example of the union of chemistry ıd mechanism, such as, if it be not a proof of con-vance, nothing is. First, as to the chemistry: how ghly concentrated must be the *venom*, which, in so ıall a quantity, can produce such powerful effects! ıd in the bee we may observe that this venom is ıde from *honey*, the only food of the insect, but the st material from which I should have expected that exalted poison could, by any process or digestion ıatsoever, have been prepared. In the next place, th respect to the mechanism, the sting is not a sim- but a compound instrument. The visible sting, ough drawn to a point exquisitely sharp, is in strict-

ness only a sheath, for, near to the extremity, may b
perceived by the microscope two minute orifices, fro
which orifices, in the act of stinging, and, as it shoul
seem, after the point of the main sting has buried itse
in the flesh, are launched out two subtile rays, whic
may be called the true or proper stings, as being thos
through which the poison is infused into the punctu
already made by the exterior sting. I have said th
chemistry and mechanism are here *united:* by whic
observation I meant, that all this machinery woul
have been useless, *telum imbelle*, if a supply of poiso
intense in quality, in proportion to the smallness of th
drop, had not been furnished to it by the chemic
elaboration which was carried on in the insect's body
and that, on the other hand, the poison, the result
this process, could not have attained its effect,
reached its enemy, if, when it was collected at the ex
tremity of the abdomen, it had not found there a ma
chinery fitted to conduct it to the external situations i
which it was to operate, *viz.* an awl to bore a hol
and a syringe to inject the fluid. Yet these attribute
though combined in their action, are independent
their origin. The venom does not breed the sting; n
does the sting concoct the venom.

IV. The *proboscis*, with which many insects a
endowed, comes next in order to be considered. It is
tube attached to the head of the animal; in the bee,
is composed of two pieces, connected by a joint: f
if it were constantly extended it would be too mu
exposed to accidental injuries; therefore, in its ind
lent state, it is doubled up by means of the joint, a

ı that position lies secure under a scaly penthouse. In ıany species of the butterfly, the proboscis, when not ı use, is coiled up like a watch-spring. In the same ee, the proboscis serves the office of the mouth, the ısect having no other; and how much better adapted is than a mouth would be, for the collecting of the roper nourishment of the animal, is sufficiently evi- ent. The food of the bee is the nectar of flowers; a rop of syrup, lodged deep in the bottom of the co- ɔllæ, in the recesses of the petals, or down the neck f a monopetalous glove. Into these cells the bee ırusts its long narrow pump, through the cavity of hich it sucks up this precious fluid, inaccessible to very other approach. It is observable also, that the lant is not the worse for what the bee does to it. The armless plunderer rifles the sweets, but leaves the ower uninjured. The ringlets of which the proboscis f the bee is composed, the muscles by which it is ex- ended and contracted, form so many microscopical onders. The agility also with which it is moved an hardly fail to excite admiration. But it is enough r our purpose to observe, in general, the suitableness the structure to the use of the means to the end, ıd especially the wisdom by which nature has de- ırted from its most general analogy, (for animals eing furnished with mouths are such,) when the ırpose could be better answered by the deviation.

In some insects the proboscis, or tongue, or trunk, is ıut up in a sharp-pointed sheath, which sheath being a much firmer texture than the proboscis itself, as ell as sharpened at the point, pierces the substance which contains the food, and then *opens within th* *wound*, to allow the inclosed tube, through which th juice is extracted, to perform its office. Can any me chanism be plainer than this is, or surpass this?

V. The *metamorphosis* of insects from grubs int moths and flies is an astonishing process. A hairy ca terpillar is transformed into a butterfly. Observe th change. We have four beautiful wings where ther were none before—a tubular proboscis in the place o a mouth with jaws and teeth, six long legs instead o fourteen feet. In another case we see a white, smooth soft worm turned into a black, hard, crustaceous beetl with gauze wings. These, as I said, are astonishin processes, and must require, as it should seem, a pro portionably artificial apparatus. The hypothesis whic appears to be most probable is, that, in the grub, ther exist at the same time three animals, one within an other, all nourished by the same digestion, and by communicating circulation, but in different stages o maturity. The latest discoveries made by naturalist seem to favor this supposition. The insect alread equipped with wings, is descried under the membrane both of the worm and nymph. In some species th proboscis, the antennæ, the limbs, and wings of the fl have been observed to be folded up within the body o the caterpillar, and with such nicety as to occupy small space only under the two first wings. Thi being so, the outermost animal which, besides its ow proper character, serves as an integument to the othe two, being the farthest advanced, dies, as we suppose and drops off first. The second, the pupa or chrysa is, then offers itself to observation. This also, in its urn, dies; its dead and brittle husk falls to pieces, nd makes way for the appearance of the fly or moth. Now if this be the case, or indeed whatever explica-ion be adopted, we have a prospective contrivance of he most curious kind; we have organizations *three leep*, yet a vascular system which supplies nutrition, rowth and life to all of them together.

VI. Almost all insects are oviparous. Nature keeps ier butterflies, moths, and caterpillars locked up during he winter in their egg-state; and we have to admire he various devices to which, if we may so speak, the ame nature hath resorted for the *security* of the egg. Many insects inclose their eggs in a silken web; others over them with a coat of hair torn from their own odies; some glue them together; and others, like the noth of the silk-worm, glue them to the leaves upon which they are deposited, that they may not be shaken ff by the wind, or washed away by rain. Some, again, nake incisions into leaves, and hide an egg in each ncision; whilst some envelop their eggs with a soft ubstance which forms the first aliment of the young nimal; and some again make a hole in the earth, nd, having stored it with a quantity of proper food, eposit their eggs in it. In all which we are to ob-erve, that the expedient depends not so much upon ne address of the animal, as upon the physical re-ources of his constitution.

The art also with which the young insect is *coiled p* in the egg presents, where it can be examined, a ubject of great curiosity. The insect, furnished with all the members which it ought to have, is rolled up into a form which seems to contract it into the least possible space; by which contraction, notwithstanding the smallness of the egg, it has room enough in its apartment, and to spare. This folding of the limbs appears to me to indicate a special direction; for if it were merely the effect of compression, the collocation of the parts would be more various than it is. In the same species, I believe, it is always the same.

These observations belong to the whole insect tribe, or to a great part of them. Other observations are limited to fewer species, but not, perhaps, less important or satisfactory.

I. The organization in the abdomen of the *silk-worm* or *spider*, whereby these insects form their *thread*, is as incontestably mechanical as a wire-drawer's mill. In the body of the silkworm are two bags, remarkable for their form, position, and use. They wind round the intestine; when drawn out they are ten inches in length, though the animal itself be only two. Within these bags is collected a glue; and, communicating with the bags, are two paps or outlets, perforated like a grater by a number of small holes. The glue or gum, being passed through these minute apertures, forms hairs of almost imperceptible fineness; and these hairs, when joined, compose the silk which we wind off from the cone in which the silkworm has wrapped itself up: in the spider, the web is formed from this thread. In both cases, the extremity of the thread, by means of its adhesive quality, is first attached by the animal to some external hold; and the end being now astened to a point, the insect, by turning round its ody, or by receding from that point, draws out the hread through the holes above described, by an operation, as hath been observed, exactly similar to the rawing of wire. The thread, like the wire, is formed y the hole through which it passes. In one respect here is a difference. The wire is the metal unaltered, xcept in figure. In the animal process the nature of e substance is somewhat changed as well as the orm; for, as it exists within the insect, it is a soft, lammy gum or glue. The thread acquires, it is robable, its firmness and tenacity from the action of e air upon its surface in the moment of exposure; nd a thread so fine is almost all surface. This proerty, however, of the paste, is part of the contrivance.

The mechanism itself consists of the bags or reseroirs into which the glue is collected, and of the exernal holes communicating with these bags; and the ction of the machine is seen in the forming of a read, as wire is formed, by forcing the material aleady prepared through holes of proper dimensions. he secretion is an act too subtile for our discernent, except as we perceive it by the produce. But ne thing answers to another; the secretory glands to e quality and consistence required in the secreted bstance; the bag to its reception. The outlets and rifices are constructed not merely for relieving the reervoirs of their burden, but for manufacturing the ontents into a form and texture of great external use, r rather, indeed, of future necessity, to the life and nctions of the insect.

II. Bees, under one character or other, have furnished every naturalist with a set of observations. I shall, in this place, confine myself to one; and that is the *relation* which obtains between the wax and the honey. No person who has inspected a bee-hive can forbear remarking how commodiously the honey is bestowed in the comb, and, amongst other advantages, how effectually the fermentation of the honey is prevented by distributing it into small cells. The fact is that when the honey is separated from the comb, and put into jars, it runs into fermentation with a much less degree of heat than what takes place in a hive. This may be reckoned a nicety; but, independently of any nicety in the matter, I would ask, what could the bee do with the honey if it had not the wax? how, at least, could it store it up for winter? The wax, therefore, answers a purpose with respect to the honey; and the honey constitutes that purpose with respect to the wax. This is a relation between them. But the two substances, though together of the greatest use, and without each other of little, come from a different origin. The bee finds the honey, but makes the wax. The honey is lodged in the nectaria of flowers, and probably undergoes little alteration—is merely collected; whereas the wax is a ductile tenacious paste, made out of a dry powder, not simply by kneeding it with a liquid, but by a digestive process in the body of the bee. What account can be rendered of facts so circumstanced, but that the animal, being intended to feed upon honey, was, by a peculiar external configuration, enabled to procure it? That oreover, wanting the honey when it could not be ocured at all, it was further endued with the no less cessary faculty of constructing repositories for its eservation? Which faculty, it is evident, must de-nd primarily upon the capacity of providing suitable aterials. Two distinct functions go to make up the ility. First, the power in the bee, with respect to ax, of loading the farina of flowers upon its thighs. icroscopic observers speak of the spoon-shaped ap-ndages with which the thighs of bees are beset for is very purpose; but, inasmuch as the art and will of e bee may be supposed to be concerned in this opera-on, there is, secondly, that which doth not rest in art or ill—a digestive faculty, which converts the loose pow-r into a stiff substance. This is a just account of the ney and the honey-comb; and this account, through ery part, carries a creative intelligence along with it.

The *sting* also of the bee has this relation to the ney, that it is necessary for the protection of a trea-re which invites so many robbers.

III. Our business is with mechanism. In the *pa-rpa* tribe of insects, there is a forceps in the tail of e male insect with which he catches and holds the male. Are a pair of pincers more mechanical than is provision in its structure? or in any structure more ear and certain in its design?

IV. St. Pierre tells us,* that in a fly with six feet do not remember that he describes the species,) the ir next the head and the pair next the tail have

* Vol. i. p. 342.

brushes at their extremities, with which the fly dresse as there may be occasion, the anterior or the posteri part of its body; but that the middle pair have n such brushes, the situation of these legs not admittin of the brushes, if they were there, being converted t the same use. This is a very exact mechanical di tinction.

V. If the reader, looking to our distributions science, wish to contemplate the chemistry as well a the mechanism of nature, the insect creation will a ford him an example. I refer to the light in the tail a *glow-worm*. Two points seem to be agreed upon b naturalists concerning it: first, that it is phosphori secondly, that its use is to attract the male insec The only thing to be inquired after is the singularit if any such there be, in the natural history of this an mal, which should render a provision of this kin more necessary for it than for other insects. Th singularity seems to be the difference which subsis between the male and the female, which differen is greater than what we find in any other species animal whatever. The glow-worm is a female *cate pillar*, the male of which is a *fly*, lively, comparative small, dissimilar to the female in appearance, prob bly also as distinguished from her in habits, pursuit and manners, as he is unlike in form and extern constitution. Here then is the adversity of the cas The caterpillar cannot meet her companion in the ai The winged rover disdains the ground. They mig never therefore be brought together did not this radia torch direct the volatile mate to his sedentary femal

In this example we also see the resources of art an-
ipated. One grand operation of chemistry is the
aking of phosphorus; and it was thought an inge-
ous device to make phosphoric matches supply the
ace of lighted tapers. Now this very thing is done
the body of the glow-worm. The phosphorus is
t only made, but kindled, and caused to emit a
eady and genial beam, for the purpose which is here
ated, and which I believe to be the true one.

VI. Nor is the last the only instance that entomolo-
affords in which our discoveries, or rather our pro-
cts, turn out to be imitations of nature. Some years
o a plan was suggested of producing propulsion by
action in this way: by the force of a steam-engine
stream of water was to be shot out of the stern of a
at, the impulse of which stream upon the water in
e river was to push the boat itself forward; it is in
th the principle by which sky-rockets ascend in the
. Of the use or practicability of the plan I am not
eaking; nor is it my concern to praise its ingenuity;
t it is certainly a contrivance. Now, if naturalists
e to be believed, it is exactly the device which na-
re has made use of for the motion of some species of
uatic insects. The larva of the *dragon-fly*, accord-
to Adams, swims by ejecting water from its tail—
lriven forward by the reaction of water in the pool
on the current issuing in a direction backward from
body.

VII. Again: Europe has lately been surprised by
elevation of bodies in the air by means of a
loon. The discovery consisted in finding out a

manageable substance, which was, bulk for bulk lighter than air; and the application of the discover was to make a body composed of this substance bea up, along with its own weight, some heavier bod which was attached to it. This expedient, so new t us, proves to be no other than what the Author of na ture has employed in the *gossamer spider.* We fre quently see this spider's thread floating in the air, an extended from hedge to hedge across a road or broo of four or five yards width. The animal which form the thread has no wings wherewith to fly from on extremity to the other of this line, nor muscles to en able it to spring or dart to so great a distance: yet it Creator hath laid for it a path in the atmosphere; an after this manner. Though the animal itself be heavie than air, the thread which it spins from its bowels i specifically lighter. This is its *balloon.* The spide left to itself, would drop to the ground; but being tie to its thread, both are supported. We have here very peculiar provision; and to a contemplative eye i is a gratifying spectacle to see this insect wafted o her thread, sustained by a levity not her own, an traversing regions which, if we examined only th body of the animal, might seem to have been forbid den to its nature.

I must now crave the reader's permission to intr duce into this place, for want of a better, an observ ion or two upon the tribe of animals, whether belong-ng to land or water, which are covered by *shells*.

I. The *shells* of *snails* are a wonderful, a mechani-al, and, if one might so speak concerning the vorks of nature, an original contrivance. Other ani-nals have their proper retreats, their hybernacula lso, or winter-quarters, but the snail carries these bout with him. He travels with his tent; and this ent, though as was necessary, both light and thin, is ompletely impervious either to moisture or air. The oung snail comes out of its egg with the shell upon s back; and the gradual enlargement which the shell eceives is derived from the slime excreted by the nimal's skin. Now the aptness of this excretion to he purpose, its property of hardening into a shell, nd the action, whatever it be, of the animal, where-y it avails itself of its gift, and of the constitution of ts glands, (to say nothing of the work being com-nenced before the animal is born,) are things which an, with no probability, be referred to any other ause than to express design; and that not on the art of the animal alone, in which design, though it night build the house, it could not have supplied the naterial. The will of the animal could not determine he quality of the excretion. Add to which, that the hell of the snail, with its pillar and convolution, is a very artificial fabric; whilst a snail, as it should seem, s the most numb and unprovided of all artificers. In he midst of variety, there is likewise a regularity which could hardly be expected. In the same species of snail the number of turns is usually, if not always, the same. The sealing up of the mouth of the shell by the snail is also well calculated for its warmth and security; but the cerate is not of the same substance with the shell.

II. Much of what has been observed of snails belongs to *shell-fish* and their *shells*, particularly to those of the univalve kind; with the addition of two remarks —one of which is upon the great strength and hardness of most of these shells. I do not know whether, the weight being given, art can produce so strong a case as are some of these shells; which defensive strength suits well with the life of an animal that has often to sustain the dangers of a stormy element and a rocky bottom, as well as the attacks of voracious fish. The other remark is upon the property, in the animal excretion, not only of congealing, but of congealing, or, as a builder would call it, *setting*, in water, and into a cretaceous substance, firm and hard. This property is much more extraordinary, and, chemically speaking, more specific, than that of hardening in the air, which may be reckoned a kind of exsiccation, like the drying of clay into bricks.

III. In the *bivalve* order of shell fish, cockles, mussels, oysters, &c. what contrivance can be so simple or so clear as the insertion, at the back, of a tough tendinous substance that becomes at once the ligament which binds the two shells together, and the *hinge* upon which they open and shut?

IV. The shell of a lobster's tail, in its articulations and overlappings, represents the jointed part of a coat of mail; or rather, which I believe to be the truth, a coat of mail is an imitation of a lobster's shell. The same end is to be answered by both; the same properties, therefore, are required in both; namely, hardness and flexibility—a covering which may guard the part without obstructing its motion. For this double purpose the art of men, expressly exercised upon the subject, has not been able to devise any thing better than what nature presents to his observation. Is not this therefore mechanism, which the mechanic, having a similar purpose in view, adopts? Is the structure of a coat of mail to be referred to art? Is the same structure of the lobster, conducing to the same use, to be referred to any thing less than art?

Some who may acknowledge the imitation, and assent to the inference which we draw from it in the instance before us, may be disposed, possibly, to ask, why such imitations are not more frequent than they are, if it be true, as we allege, that the same principle of intelligence, design, and mechanical contrivance was exerted in the formation of natural bodies as we employ in the making of the various instruments by which our purposes are served? The answers to this question, are, first, that it seldom happens that precisely the same purpose, and no other, is pursued in any work which we compare of nature and of art; secondly, that it still more seldom happens that we *can* imitate nature if we would. Our materials and our workmanship are equally deficient. Springs and wires, and cork and leather, produce a poor substitute for an arm or a hand. In the example which we have selected, I mean a lobster's shell compared with a coat of mail, these difficulties stand less in the way than in almos any other that can be assigned; and the consequenc is, as we have seen, that art gladly borrows from na- ture her contrivance, and imitates it closely.

But to return to insects. I think it is in this class o animals, above all others, especially when we take i the multitude of species which the microscope disco vers, that we are struck with what Cicero has calle "the *insatiable* variety of nature." There are said t be six thousand species of flies; seven hundred an sixty butterflies; each different from all the rest. (St Pierre.) The same writer tells us, from his own obse vation, that thirty-seven species of winged insect with distinctions well expressed, visited a single straw berry-plant in the course of three weeks.* Ray observ ed, within the compass of a mile or two of his ow house, two hundred kinds of butterflies, nocturnal an diurnal. He likewise asserts, but, I think, without an grounds of exact computation, that the number c species of insects, reckoning all sorts of them, ma not be short of ten thousand.† And in this vast variet of animal forms, (for the observation is not confined t insects, though more applicable perhaps to them tha to any other class,) we are sometimes led to take notic

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* Vol. i. p. 3. † Wisd. of God, p. 23.

the different methods, or rather of the studiously versified methods, by which one and the same purse is attained. In the article of breathing, for example, which was to be provided for in some way or ner, besides the ordinary varieties of lungs, gills, and eathing-holes, (for insects in general respire, not the mouth, but through holes in the sides,) the mphæ of gnats have an apparatus to raise their *cks* to the top of the water, and so take breath. The dro-canthari do the like by thrusting their *tails* out the water.* The maggot of the eruca labra has a g tail, one part sheathed within another, (but which can draw out at pleasure,) with a starry tuft at the d, by which *tuft*, when expanded upon the surface, insect both supports itself in the water, and draws the air which is necessary. In the article of natural thing, we have the skins of animals invested with les, hair, feathers, mucus, froth, or itself turned into shell or crust. In the no less necessary article of offence and defence, we have teeth, talons, beaks, horns, ngs, prickles, with (the most singular expedient for e same purpose) the power of giving the electric ock, and, as is credibly related of some animals, of iving away their pursuers by an intolerable fœtor, or blackening the water through which they are pursued. The consideration of these appearances might luce us to believe that *variety* itself, distinct from ery other reason, was a motive in the mind of the eator, or with the agents of his will.

* Derham, p. 7.

To this great variety in organized life the Deity ha given, or perhaps there arises out of it, a correspondin variety of animal *appetites*. For the final cause this we have not far to seek. Did all animals cov the same element, retreat, or food, it is evident ho much fewer could be supplied and accommodate than what at present live conveniently together, an find a plentiful subsistence. What one nature reject another delights in. Food which is nauseous to or tribe of animals becomes, by that very property whic makes it nauseous, an alluring dainty to another trib Carrion is a treat to dogs, ravens, vultures, fish. Th exhalations of corrupted substances attract flies b crowds. Maggots revel in putrefaction.

CHAPTER XX.

OF PLANTS.

I think a designed and studied mechanism to be general more evident in animals than in *plants;* ar it is unnecessary to dwell upon a weaker argume where a stronger is at hand. There are, however, few observations upon the vegetable kingdom whic lie so directly in our way, that it would be improper pass by them without notice.

The one great intention of nature in the structure of nts seems to be the perfecting of the *seed*, and, what part of the same intention, the preserving of it until be *perfected*. This intention shows itself, in the first ce, by the care which appears to be taken to protect d ripen, by every advantage which can be given to m of situation in the plant, those parts which most mediately contribute to fructification, viz. the an- ræ, the stamina, and the stigmata. These parts are ally lodged in the centre, the recesses, or the la- rinths of the flower—during their tender and imma- e state are shut up in the stalk, or sheltered in the d—as soon as they have acquired firmness of tex- e sufficient to bear exposure, and are ready to per- m the important office which is assigned to them, y are disclosed to the light and air by the bursting the stem or the expansion of the petals; after which y have, in many cases, by the very form of the wer during its blow, the light and warmth reflected on them from the concave side of the cup. What is led also the *sleep* of plants is the leaves or petals posing themselves in such a manner as to shelter young stems, buds, or fruit. They turn up, or y fall down, according as this purpose renders either nge of position requisite. In the growth of corn, enever the plant begins to shoot, the two upper ves of the stalk join together, embrace the ear, and tect it till the pulp has acquired a certain degree consistency. In some water-plants the flowering d fecundation are carried on *within* the stem, ich afterwards opens to let loose the impregnated seed.* The *pea*, or papilionaceous tribe, inclose the pa of fructification within a beautiful folding of the int nal blossom, sometimes called, from its shape, the b or keel—itself also protected under a penthouse for ed by the external petals. This structure is very art cial; and what adds to the value of it, though it m diminish the curiosity, very general. It has also t further advantage, (and it is an advantage strictly r chanical,) that all the blossoms turn their *backs* to wind whenever the gale blows strong enough to danger the delicate parts upon which the seed depen I have observed this a hundred times in a field of p in blossom. It is an aptitude which results from figure of the flower, and, as we have said, is stric mechanical, as much so as the turning of a weath board or tin-cap upon the top of a chimney. Of *poppy*, and of many similar species of flowers, head while it is growing hangs down, a rigid cur ture in the upper part of the stem giving to it that sition; and in that position it is impenetrable by r or moisture. When the head has acquired its size is ready to open, the stalk *erects* itself for the purp as it should seem, of presenting the flower, and w the flower the instruments of fructification, to genial influence of the sun's rays. This always stru me as a curious property, and specifically as well originally provided for in the constitution of the pla for if the stem be only bent by the weight of the he how comes it to straighten itself when the head is

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* Philos. Transact. part. ii. 1796, p. 502.

eaviest? These instances show the attention of na-re to this principal object, the safety and maturation ' the parts upon which the seed depends.

In *trees*, especially in those which are natives of lder climates, this point is taken up earlier. Many of ese trees (observe in particular the *ash* and the *horse-estnut*) produce the embryos of the leaves and flow-s in one year, and bring them to perfection the fol-wing. There is a winter therefore to be gotten over. ow what we are to remark is, how nature has pre-red for the trials and severities of that season. These nder embryos are, in the first place, wrapped up with compactness which no art can imitate; in which ate they compose what we call the bud. This is not l. The bud itself is inclosed in scales; which scales e formed from the remains of past leaves, and the diments of future ones. Neither is this the whole. the coldest climates, a third preservative is added, the bud having a *coat* of gum or resin, which, ing congealed, resists the strongest frosts. On the proach of warm weather, this gum is softened, and ases to be a hinderance to the expansion of the ves and flowers. All this care is part of that sys-n of provisions which has for its object and consum-ation the production and perfecting of the seeds.

The SEEDS themselves are packed up in a *capsule*, vessel composed of coats, which, compared with the st of the flower, are strong and tough. From this ssel projects a tube, through which tube the farina, some subtile fecundating effluvium that issues from is admitted to the seed. And here also occurs a me-

chanical variety, accommodated to the different c
cumstances under which the same purpose is to
accomplished. In flowers which are erect, the pistil
shorter than the stamina; and the pollen, shed fr
the antheræ into the cup of the flower, is caught in
descent by the head of the pistil, called the stign
But how is this managed when the flowers ha
down, (as does the crown-imperial for instance,) a
in which position, the farina, in its fall, would be c
ried from the stigma, and not towards it? The re
tive length of the parts is now inverted. The pistil
these flowers is usually longer, instead of shorter, th
the stamina, that its protruding summit may recei
the pollen as it drops to the ground. In some cases,
in the *nigella,*) where the shafts of the pistils or sti
are disproportionably long, they bend down their
tremities upon the antheræ, that the necessary appro
imation may be effected. But (to pursue this gr
work in its progress) the impregnation, to which
this machinery relates, being completed, the oth
parts of the flower fade and drop off, whilst the *gr
vid seed-vessel,* on the contrary, proceeds to increa
its bulk, always to a great, and, in some species
the gourd, for example, and melon,) to a surprisi
comparative size; assuming in different plants an i
calculable variety of forms, but all evidently conduci
to the security of the seed. By virtue of this proce
so necessary, but so diversified, we have the seed
length, in stone-fruits and nuts, incased in a stro
shell, the shell itself inclosed in a pulp or husk,
which the seed within is, or hath been, fed; or, mo

nerally (as in grapes, oranges, and the numerous nds of berries) plunged overhead in a glutinous rup, contained within a skin or bladder: at other nes (as in apples and pears) embedded in the heart a firm fleshy substance; or (as in strawberries) icked into the surface of a soft pulp.

These and many more varieties exist in what we ll *fruits.** In pulse, and grain, and grasses; in trees d shrubs, and flowers; the variety of the seed-ves-

* From the conformation of fruits alone, one might be led, even without perience, to suppose that part of this provision was destined for the lities of animals. As limited to the plant, the provision itself seems to beyond its object. The flesh of an apple, the pulp of an orange, the at of a plum, the fatness of the olive, appear to be *more* than sufficient the nourishing of the seed or kernel. The event shows that this redun-ncy, if it be one, ministers to the support and gratification of animal na-es; and when we observe a provision to be more than sufficient for one rpose, yet wanted for another purpose, it is not unfair to conclude that h purposes were contemplated together. It favors this view of the sub-t to remark, that fruits are not (which they might have been) ready all gether, but that they ripen in succession throughout a great part of the ır; some in summer; some in autumn; that some require the slow turation of the winter, and supply the spring; also that the coldest its grow in the hottest places. Cucumbers, pine-apples, melons, are natural produce of warm climates, and contribute greatly, by their lness, to the refreshment of the inhabitants of those countries.

I will add to this note the following observation communicated to me Mr. Brinkley.

"The eatable part of the cherry or peach first serves the purposes of fecting the seed or kernel, by means of vessels passing through the ne, and which are very visible in a peach-stone. After the kernel is per-ted, the stone becomes hard, and the vessels cease their functions. But substance surrounding the stone is not then thrown away as useless. at which was before only an instrument for perfecting the kernel, now eives and retains to itself the whole of the sun's influence, and thereby omes a grateful food to man. Also what an evident mark of design is stone protecting the kernel! The intervention of the stone prevents the ond use from interfering with the first."

sels is incomputable. We have the seeds (as in the tribe) regularly disposed in parchment pods, whi though soft and membranous, completely exclude wet even in the heaviest rains; the pod also, not dom (as in the bean) lined with a fine down; at ot times (as in the senna) distended like a blown bladd or we have the seed enveloped in wool (as in the ton-plant) lodged (as in pines) between the hard compact scales of a cone, or barricadoed (as in the a choke and thistle) with spikes and prickles; in mu rooms, placed under a penthouse; in ferns, wit slits in the back part of the leaf: or (which is most general organization of all) we find them cov ed by strong, close tunicles, and attached to the st according to an order appropriated to each plant, as seen in the several kinds of grains and of grasses.

In which enumeration, what we have first to not is, unity of purpose under variety of expedients. thing can be more *single* than the design; more *versified* than the means. Pellicles, shells, pulps, po husks, skin, scales armed with thorns, are all empl ed in prosecuting the same intention. Secondly: may observe, that, in all these cases, the purpose fulfilled within a just and *limited* degree. We c perceive, that if the seeds of plants were more stror ly guarded than they are, their greater security wou interfere with other uses. Many species of anim would suffer, and many perish, if they could not tain access to them. The plant would overrun t soil; or the seed be wasted for want of room to s itself. It is sometimes as necessary to destroy partic ır species of plants, as it is, at other times, to encou- ıge their growth. Here, as in many cases, a balance to be maintained between opposite uses. The pro- isions for the preservation of seeds appear to be di- ected chiefly against the inconstancy of the elements, the sweeping destruction of inclement seasons. 'he depredation of animals, and the injuries of acci- ental violence, are allowed for in the abundance of ıe increase. The result is, that out of the many thou- ınd different plants which cover the earth, not a single ›ecies, perhaps, has been lost since the creation.

When nature has perfected her seeds, her next care to disperse them. The seed cannot answer its ırpose while it remains confined in the capsule. fter the seeds therefore are ripened, the pericarpium ›ens to let them out; and the opening is not like an ccidental bursting, but for the most part, is according a certain rule in each plant. What I have always ıought very extraordinary, nuts and shells, which we ın hardly crack with our teeth, divide and make way r the little tender sprout which proceeds from the ernel. Handling the nut, I could hardly conceive ›w the plantule was ever to get out of it. There are ıses, it is said, in which the seed-vessel, by an elastic rk, at the moment of its explosion, casts the seeds to distance. We all however know, that many seeds ıose of most composite flowers, as of the thistle, ındelion, &c.) are endowed with what are not im- operly called *wings*; that is downy appendages, by hich they are enabled to float in the air, and are car- ed oftentimes by the wind to great distances from the plant which produces them. It is the swelling also o this downy tuft within the seed-vessel that seems t overcome the resistance of its coats, and to open passage for the seed to escape.

But the *constitution* of seeds is still more admirabl than either their preservation or their dispersion. I the body of the seed of every species of plant, o nearly of every one, provision is made for two gran purposes: first, for the safety of the *germ*, secondl for the temporary support of the future plant. Th sprout, as folded up in the seed, is delicate and britt beyond any other substance. It cannot be touche without being broken. Yet, in beans, peas, grass-seed grain, fruits, it is so fenced on all sides, so shut up an protected, that, whilst the seed itself is rudely handle tossed into sacks, shoveled into heaps, the sacred pa ticle, the miniature plant, remains unhurt. It is wonde ful how long many kinds of seeds, by the help of the integuments, and perhaps of their oils, stand out again decay. A grain of mustard-seed has been known t lie in the earth for a hundred years; and, as soon a it has acquired a favorable situation, to shoot a vigorously as if just gathered from the plant. The as to the second point, the temporary support of th future plant, the matter stands thus. In grain, an pulse, and kernels, and pippins, the germ composes very small part of the seed. The rest consists of nutritious substance, from which the sprout draws i aliment for some considerable time after it is put fort viz. until the fibres, shot out from the other end of th seed, are able to imbibe juices from the earth in ufficient quantity for its demand. It is owing to his constitution, that we see seeds sprout, and the prouts make a considerable progress, without any arth at all. It is an economy, also, in which we re-nark a close analogy between the seeds of plants and he eggs of animals. The same point is provided for n the same manner in both. In the egg, the residence f the living principle, the cicatrix, forms a very mi-ute part of the contents. The white and the white nly is expended in the formation of the chicken. The yolk, very little altered or diminished, is wrapped p in the abdomen of the young bird, when it quits he shell; and serves for its nourishment till it have earned to pick its own food. This perfectly resembles he first nutrition of a plant. In the plant, as well as n the animal, the structure has every character of ontrivance belonging to it; in both it breaks the ransition from prepared to unprepared aliment; in oth, it is prospective and compensatory. In animals which suck, this intermediate nourishment is supplied y a different source.

In all subjects, the most common observations are he best, when it is their truth and strength which ave made them common. There are, of this sort, *two* oncerning plants, which it falls within our plan to otice. The *first* relates to what has already been ouched upon, their germination. When a grain of orn is cast into the ground, this is the change which akes place. From one end of the grain issues a great prout; from the other, a number of white fibrous hreads. How can this be explained? Why not sprouts from both ends? why not fibrous thread from both ends? To what is the difference to be re ferred, but to design; to the different uses which th parts are therefore to serve; uses which discover them selves in the sequel of the process? The sprout, o plumule, struggles into the air; and becomes th plant, of which, from the first, it contained the rudi ments: the fibres shoot into the earth; and thereb both fix the plant to the ground, and collect nourish ment from the soil for its support. Now, what is no a little remarkable, the parts issuing from the see take their respective directions, into whatever positio the seed itself happens to be cast. If the seed b thrown into the wrongest possible position; that is, i the ends point in the ground the reverse of what the ought to do, every thing, nevertheless, goes on righ The sprout, after being pushed down a little way makes a bend, and turns upwards; the fibres, on th contrary, after shooting at first upwards, turn down Of this extraordinary vegetable fact, an account ha lately been attempted to be given. "The plumule (i is said) is stimulated by the *air* into action, and elon gates itself when it is thus most excited; and the radi cle is stimulated by *moisture*, and elongates itself whe *it* is thus most excited. Whence one of these grow upward in quest of its adapted object, and the othe downward."* Were this account better verified b experiment than it is, it only shifts the contrivance It does not disprove the contrivance; it only remove

* Darwin's Phytologia, p. 144.

it a little further back. Who, to use our author's own language, "*adapted* the objects?" Who gave such a quality to these connate parts as to be susceptible of *different* "stimulation;" as to be "excited" each only by its own element, and precisely by that which the success of the vegetation requires? I say, "which the success of the vegetation requires;" for the toil of the husbandman would have been in vain, the laborious and expensive preparation of the ground in vain; if the event must, after all, depend upon the position in which the scattered seed was sown. Not one seed out of a hundred would fall in a right direction.

Our *second* observation is upon a general property of climbing plants, which is strictly mechanical. In these plants, from each knot or joint, or as botanists call it, axilla, of the plant, issue, close to each other, two shoots, one bearing the flower and fruit, the other drawn out into a wire, a long, tapering, spiral tendril, that twists itself round any thing which lies within its reach. Considering that in this class two purposes are to be provided for, (and together) fructification and support, the fruitage of the plant and the sustentation of the stalk, what means could be used more effectual, or, as I have said, more mechanical, than what this structure presents to our eyes? Why, or how, without a view to this double purpose, do two shoots, of such different and appropriate forms, spring from the same point, from contiguous points of the same stalk? It never happens thus in robust plants, or in trees. "We see not," says Ray, "so much as one tree, or shrub, or herb, that hath a firm and strong stem, and that is able to mount up and stand alone without assistance, *furnished with these tendrils*." Make only so simple a comparison as that between a pea and a bean. Why does the pea put forth tendrils, the bean not? but because the stalk of the pea cannot support itself, the stalk of the bean can. We may add also, as a circumstance not to be overlooked, that, in the pea tribe, these clasps do not make their appearance till they are wanted—till the plant has grown to a height to stand in need of support.

This word "support" suggests to us a reflection upon a property of grasses, of corn, and canes. The hollow stems of these classes of plants are set at certain intervals with joints. These joints are not found in the trunks of trees, or in the solid stalks of plants. There may be other uses of these joints; but the fact is, and it appears to be at least one purpose designed by them, that they *corroborate* the stem, which by its length and hollowness would otherwise be too liable to break or bend.

Grasses are Nature's care. With these she clothes the earth—with these she sustains its inhabitants. Cattle feed upon their leaves—birds upon their smaller seeds—men upon the larger; for few readers need to be told that the plants which produce our bread-corn belong to this class. In those tribes which are more generally considered as grasses, their extraordinary means and powers of preservation and increase, their hardiness, their almost unconquerable disposition to spread, their faculties of reviviscence, coincide with the intention of Nature concerning them. They thrive nder a treatment by which other plants are destroyed. The more their leaves are consumed, the more their oots increase. The more they are trampled upon, the hicker they grow. Many of the seemingly dry and ead leaves of grasses revive, and renew their verdure n the spring. In lofty mountains, where the summer eats are not sufficient to ripen the seeds, grasses bound which are viviparous, and consequently able propagate themselves without seed. It is an obser-ation likewise which has often been made, that her-ivorous animals attach themselves to the leaves of rasses, and if at liberty in their pastures to range and hoose, leave untouched the straws which support the owers.*

The GENERAL properties of vegetable nature, or pro-erties common to large portions of that kingdom, are lmost all which the compass of our argument allows s to bring forward. It is impossible to follow plants nto their several species. We may be allowed, how-ver, to single out three or four of these species as orthy of a particular notice, either by some singular echanism, or by some peculiar provision, or by both.

I. In Dr. Darwin's Botanic Garden, (l. 395, note,) is e following account of the *vallisneria*, as it has been bserved in the river Rhone:—"They have roots at e bottom of the Rhone. The flowers of the *female lant* float on the surface of the water, and are furnish-d with an *elastic spiral stock*, which extends or con-acts as the water rises or falls—this rise or fall, from

* Withering, Bot. Arr. vol. i. p. 28, ed. 2nd.

the torrents which flow into the river, often amounting to many feet in a few hours. The flowers of the *male plant* are produced under water; and as soon as the fecundating farina is mature, they separate themselves from the plant, rise to the surface, and are wafted by the air, or borne by the currents, to the female flowers." Our attention in this narrative will be directed to two particulars: first to the mechanism, the "elastic spiral stalk," which lengthens or contracts itself according as the water rises or falls; secondly, to the provision which is made for bringing the male flower, which is produced *under* water, to the female flower, which floats upon the surface.

II. My second example I take from Withering's Arrangement, vol. ii, 209, ed. 3. "The *cuscuta europæa* is a parasitical plant. The seed opens, and puts forth a *little spiral body,* which does *not* seek the earth to take root, but *climbs* in a spiral direction, from right to left, up other plants, from which, by means of vessels, it draws its nourishment." The "little spiral body" proceeding from the seed is to be compared with the fibres which seeds send out in ordinary cases; and the comparison ought to regard both the form of the threads and the direction. They are straight; this is spiral. They shoot downwards; this points upwards. In the rule and in the exception we equally perceive design.

III. A better known parasitical plant is the evergreen shrub, called the *misseltoe.* What we have to remark in it is a singular instance of *compensation.* No art hath yet made these plants take root in the arth. Here, therefore, might seem to be a mortal de-ect in their constitution. Let us examine how this efect is made up to them. The seeds are endued ith an adhesive quality so tenacious, that, if they be ıbbed upon the smooth bark of almost any tree, they ill stick to it. And then what follows? Roots, spring-g from these seeds, insinuate their fibres into the oody substance of the tree; and the event is, that a isseltoe plant is produced next winter.* Of no other ant do the roots refuse to shoot in the ground; of no her plant do the seeds possess this adhesive, genera-ve quality, when applied to the bark of trees.

IV. Another instance of the *compensatory* system in the autumnal crocus, or meadow saffron, (*colchi-m autumnale.*) I have pitied this poor plant a thou-nd times. Its blossom rises out of the ground in the ost forlorn condition possible; without a sheath, a nce, a calyx, or even a leaf to protect it: and that, ot in the spring, to be visited by summer suns, but ıder all the disadvantages of the declining year. hen we come, however, to look more closely into e structure of this plant, we find that, instead of its ing neglected, Nature has gone out of her course to ovide for its security, and to make up to it for all its fects. The seed-vessel, which in other plants is situ-ed within the cup of the flower, or just beneath it, this plant lies buried ten or twelve inches under ound within the bulbous root. The tube of the flow-, which is seldom more than a few tenths of an inch

* Withering, Bot. Arr. vol. 1, p. 203, ed. 2d.

long, in this plant extends down to the root. The styl
in all cases reach the seed-vessel; but it is in this l
an elongation unknown to any other plant. All the
singularities contribute to one end. "As this pla
blossoms late in the year, and probably would n
have time to ripen its seeds before the access of wi
ter, which would destroy them, Providence has co
trived its structure such, that this important office ma
be performed at a depth in the earth out of reach
the usual effects of frost."* That is to say, in the a
tumn nothing is done above ground but the busine
of impregnation; which is an affair between the a
theræ and the stigmata, and is probably soon ove
The maturation of the impregnated seed, which
other plants proceeds within a capsule, exposed tog
ther with the rest of the flower to the open air, is he
carried on, and during the whole winter, within th
heart, as we may say, of the earth, that is, "out
the reach of the usual effects of frost." But then
new difficulty presents itself. Seeds, though perfecte
are known not to vegetate at this depth in the eart
Our seeds, therefore, though so safely lodged, woul
after all, be lost to the purpose for which all seeds a
intended. Lest this should be the case, "a second a
mirable provision is made to raise them above the su
face when they are perfected, and to sow them at
proper distance:" viz. the germ grows up *in the sprin*
upon a fruit-stalk, accompanied with leaves. Th
seeds now, in common with those of other plant

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* Withering, ubi supra, p. 360.

ave the benefit of the summer, and are sown upon
ıe surface. The order of vegetation externally is this; ıe plant produces its flowers in September; its leaves nd fruits in the spring following.

V. I give the account of the *dionæa muscipula*, an xtraordinary American plant, as some late authors ave related it: but whether we be yet enough acuainted with the plant to bring every part of this acount to the test of repeated and familiar observation, am unable to say, "Its leaves are jointed, and furished with two rows of strong prickles; their surfaces overed with a number of minute glands, which seete a sweet liquor that allures the approach of flies. /hen these parts are touched by the legs of flies, the vo lobes of the leaf instantly spring up, the rows of ickles lock themselves fast together, and squeeze the ıwary animal to death."* Here, under a new model, e recognise the ancient plan of nature, viz. the relaon of parts and provisions to one another, to a common office, and to the utility of the organized body to hich they belong. The attracting syrup, the rows of rong prickles, their position so as to interlock the ints of the leaves; and, what is more than the rest, at singular irritability of their surfaces, by which ey close at a touch; all bear a contributory part in oducing an effect, connected either with the defence with the nutrition of the plant."

* Smellie's Phil. of Nat. Hist. vol. 1, p. 5.

CHAPTER XXI.

THE ELEMENTS.

When we come to the elements, we take leave
our mechanics; because we come to those things,
the organization of which, if they be organized,
are confessedly ignorant. This ignorance is impli
by their name. To say the truth, our investigatio
are stopped long before we arrive at this point. B
then it is for our comfort to find, that a knowledge
the constitution of the elements is not necessary
us. For instance, as Addison has well observed, "
know *water* sufficiently, when we know how to bo
how to freeze, how to evaporate, how to make it fres
how to make it run or spout out, in what quantity a
direction we please, without knowing what water is
The observation of this excellent writer has mo
propriety in it now than it had at the time it w
made; for the constitution and the constituent parts
water appear in some measure to have been lately di
covered; yet it does not, I think, appear, that we ca
make any better or greater use of water since the di
covery than we did before it.

We can never think of the elements, without r
flecting upon the number of distinct uses which a
consolidated in the same substance. The *air* suppli
the lungs, supports fire, conveys sound, reflects ligh
diffuses smells, gives rain, wafts ships, bears up bird

Ἐξ ὕδατος τα παντα : *water*, besides maintaining ts own inhabitants, is the universal nourisher of plants, and through them of terrestrial animals; is he basis of their juices and fluids; dilutes their food; quenches their thirst; floats their burdens. *Fire* warms, dissolves, enlightens: is the great promoter of regetation and life, if not necessary to the support of both.

We might enlarge, to almost any length we please, upon each of these uses; but it appears to me almost sufficient to state them. The few remarks, which I udge it necessary to add, are as follow:—

I. Air is essentially different from earth. There appears to be no necessity for an atmosphere's investing our globe; yet it does invest it: and we see how many, how various, and how important are the purposes which it answers to every order of animated, not to say of organized, beings, which are placed upon the errestrial surface. I think that every one of these uses will be understood upon the first mention of hem, except it be that of *reflecting* light, which may be explained thus:—If I had the power of seeing only by means of rays coming directly from the sun, whenever I turned my back upon the luminary I should find myself in darkness. If I had the power of seeing by reflected light, yet by means only of light reflected from solid masses, these masses would shine indeed, and glisten, but it would be in the dark. The hemisphere, the sky, the world, could only be *illuminated*, as it is illuminated, by the light of the sun being from all sides, and in every direction, reflected to the eye, by particles, as numerous, as thickly scattered, and a widely diffused, as are those of the air.

Another general quality of the atmosphere is th power of evaporating fluids. The adjustment of th quality to our use is seen in its action upon the se In the sea, water and salt are mixed together most i timately; yet the atmosphere raises the water an leaves the salt. Pure and fresh as drops of rain d scend, they are collected from brine. If evaporatio be solution, (which seems to be probable,) then the a dissolves the water, and not the salt. Upon whatev it be founded, the distinction is critical: so much s that when we attempt to imitate the process by a we must regulate our distillation with great care a nicety, or, together with the water, we get the bitte ness, or at least the distatefulness, of the marine su stance;—and, after all, it is owing to this original ele tive power in the air, that we can effect the separatio which we wish, by any art or means whatever.

By evaporation, water is carried up into the air; b the converse of evaporation, it falls down upon th earth. And how does it fall? Not by the clouds bein all at once re-converted into water, and descendin like a sheet; not in rushing down in columns from spout; but in moderate drops, as from a colande Our watering-pots are made to imitate showers rain. Yet, *à priori*, I should have thought either the two former methods more likely to have take place than the last.

By respiration, flame, putrefaction, air is rendere unfit for the support of animal life. By the consta peration of these corrupting principles, the whole atnosphere, if there were no restoring causes, would ome at length to be deprived of its necessary degree f purity. Some of these causes seem to have been iscovered, and their efficacy ascertained by experinent; and so far as the discovery has proceeded, it pens to us a beautiful and a wonderful economy. *Vegetation* proves to be one of them. A sprig of mint, orked up with a small portion of foul air, placed in ne light, renders it again capable of supporting light r flame. Here, therefore, is a constant circulation of enefits maintained between the two great provinces f organized nature. The plant purifies what the nimal has poisoned; in return, the contaminated air s more than ordinarily nutritious to the plant. *Agitaion with water* turns out to be another of these restoratives. The foulest air, shaken in a bottle with vater for a sufficient length of time, recovers a great egree of its purity. Here then again, allowing for ne scale upon which nature works, we see the saluary effects of *storms* and *tempests*. The yesty waves vhich confound the heaven and the sea, are doing the ery thing which was done in the bottle. Nothing can e of greater importance to the living creation, than ne salubrity of their atmosphere. It ought to reconle us, therefore, to these agitations of the elements, f which we sometimes deplore the consequences, to now that they tend powerfully to restore to the air nat purity which so many causes are constantly npairing.

II. In Water, what ought not a little to be admired,

are those negative qualities which constitute its *puri*
Had it been vinous, or oleaginous, or acid; had t
sea been filled, or the rivers flowed, with wine or mi
fish, constituted as they are, must have died; plan
constituted as they are, would have withered; t
lives of animals which feed upon plants must ha
perished. Its very *insipidity*, which is one of tho
negative qualities, renders it the best of all menstru
Having no taste of its own, it becomes the since
vehicle of every other. Had there been a taste
water, be it what it might, it would have infect
every thing we ate or drank, with an importunate r
petition of the same flavor.

Another thing in this element, not less to be admire
is the constant *round* which it travels; and by whic
without suffering either adulteration or waste, it
continually offering itself to the wants of the habitab
globe. From the sea are exhaled those vapors whi
form the clouds: these clouds descend in showe
which penetrating into the crevices of the hills, supp
springs; which springs flow in little streams into t
valleys; and there uniting, become rivers; whi
rivers, in return, feed the ocean. So there is an ince
sant circulation of the same fluid; and not one dr
probably more or less now than there was at the cre
tion. A particle of water takes its departure from t
surface of the sea, in order to fulfil certain importa
offices to the earth: and having executed the servi
which was assigned to it, returns to the bosom whic
it left.

Some have thought that we have too much wat pon the globe, the sea occupying above three-quarrs of its whole surface. But the expanse of ocean, nmense as it is, may be no more than sufficient to rtilize the earth. Or, independently of this reason, I now not why the sea may not have as good a right its place as the land. It may proportionably support many inhabitants; minister to as large an aggregate enjoyment. The land only affords a habitable surce; the sea is habitable to a great depth.

III. Of Fire, we have said that it *dissolves*. The ly idea probably which this term raised in the read's mind, was that of fire melting metals, resins, and me other substances, fluxing ores, running glass, and sisting us in many of our operations, chemical or linary. Now these are only uses of an occasional nd, and give us a very imperfect notion of what fire es for us. The grand importance of this dissolving wer, the great office indeed of fire in the economy nature, is keeping things in a state of solution—at is to say, in a state of fluidity. Were it not for e presence of heat, or of a certain degree of it, all ids would be frozen. The ocean itself would be a arry of ice; universal nature stiff and dead.

We see, therefore, that the elements bear not only strict relation to the constitution of organized bodies, t a relation to each other. Water could not perform office to the earth without air; nor exist as water, thout fire.

IV. Of Light (whether we regard it as of the same bstance with fire, or as a different substance) it is ogether superfluous to expatiate upon the use. No man disputes it. The observations, therefore, whi I shall offer, respect that little which we seem know of its constitution.

Light travels from the sun at the rate of twel millions of miles in a minute. Urged by such a ve city, with what *force* must its particles drive agai (I will not say the eye, the tenderest of animal su stances, but) every substance, animate or inanima which stands in its way! It might seem to be a for sufficient to shatter to atoms the hardest bodies.

How then is this effect, the consequence of su prodigious velocity, guarded against? By a prop tionable *minuteness* of the particles of which light composed. It is impossible for the human mind imagine to itself any thing so small as a particle light. But this extreme exility, though difficult to co ceive, it is easy to prove. A drop of tallow, exper ed in the wick of a farthing candle, shall send for rays sufficient to fill a hemisphere of a mile diamete and to fill it so full of these rays, that an aperture n larger than the pupil of an eye, wherever it be plac within the hemisphere, shall be sure to receive som of them. What floods of light are continually pour from the sun, we cannot estimate; but the immensi of the sphere which is filled with particles, even if reached no further than the orbit of the earth, we ca in some sort compute; and we have reason to believ that, throughout this whole region, the particles light lie, in latitude at least, near to one another. Th spissitude of the sun's rays at the earth is such, th the number which falls upon the burning-glass of a

diameter is sufficient, when concentrated, to set
d on fire.

he tenuity and the velocity of the particles of
t, as ascertained by separate observations, may be
to be proportioned to each other, both surpassing
utmost stretch of comprehension; but propor-
ed. And it is this proportion alone which converts
mendous element into a welcome visiter.

has been observed to me by a learned friend, as
ng often struck his mind, that, if light had been
e by a common artist, it would have been of one
orm *color:* whereas by its present composition,
have that variety of colors which is of such infinite
to us for the distinguishing of objects; which adds
uch to the beauty of the earth, and augments the
k of our innocent pleasures.

Vith which may be joined another reflection, viz.
at, considering light as compounded of rays of
en different colors (of which there can be no
bt, because it can be resolved into these rays by
ply passing it through a prism,) the constituent
must be well mixed and blended together to
uce a fluid so clear and colorless as a beam of
t is, when received from the sun.

CHAPTER XXII.

ASTRONOMY.*

My opinion of Astronomy has always been that
not the best medium through which to prove the age
of an intelligent Creator; but that, this being pro
it shows, beyond all other sciences, the magnific
of his operations. The mind which is once convin
it raises to sublimer views of the Deity than any o
subject affords; but it is not so well adapted as s
other subjects are to the purpose of argument.
are destitute of the means of examining the cons
tion of the heavenly bodies. The very simplicit
their appearances is against them. We see noth
but bright points, luminous circles, or the phase
spheres reflecting the light which falls upon th
Now we deduce design from relation, aptitude,
correspondence of *parts*. Some degree, therefore
complexity is necessary to render a subject fit for
species of argument. But the heavenly bodies do
except perhaps in the instance of Saturn's ring,
sent themselves to our observation as compounded
parts at all. This, which may be a perfection in th

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* For the articles of this chapter marked with an asterisk, I an
debted to some obliging communications received (through the han
the Lord Bishop of Elphin) from the Rev. J. Brinkley, M. A. Andr
Professor of Astronomy in the University of Dublin.

disadvantage to us, as inquirers after their nature. ey do not come within our mechanics.

And what we say of their forms is true of their *motions*. Their motions are carried on without any sible intermediate apparatus; whereby we are cut from one principle ground of argumentation—angy. We have nothing wherewith to compare m; no invention, no discovery, no operation or rerce of art, which, in this respect, resembles them. en those things which are made to imitate and resent them—such as orreries, planetaria, celestial bes, &c. bear no affinity to them, in the cause and nciple by which their motions are actuated. I can ign for this difference a reason of utility—viz. a son why, though the action of *terrestial* bodies n each other be, in almost all cases, through the ervention of solid or fluid substances, yet central action does not operate in this manner. It was nesary that the intervals between the planetary orbs uld be devoid of any *inert* matter, either fluid or d, because such an intervening substance would, its resistance, destroy those very motions which action is employed to preserve. This may be a l cause of the difference; but still the difference troys the analogy.

Our ignorance, moreover, of the *sensitive* natures which other planets are inhabited, necessarily keeps n us the knowledge of numberless utilities, relas, and subserviencies, which we perceive upon our n globe.

After all; the real subject of admiration is, that we

understand so much of astronomy as we do. That
animal confined to the surface of one of the plane
bearing a less proportion to it than the smallest
croscopic insect does to the plant it lives upon; t
this little, busy, inquisitive creature, by the use
senses which were given to it for its domestic nec
sities, and by means of the assistance of those sen
which it has had the art to procure, should have b
enabled to observe the whole system of worlds
which its own belongs; the changes of place of
immense globes which compose it; and with such
curacy as to mark out beforehand the situation in
heavens in which they will be found at any fut
point of time; and that these bodies, after sail
through regions of void and trackless space, sho
arrive at the place where they were expected,
within a minute, but within a few seconds of a min
of the time prefixed and predicted: all this is wond
ful, whether we refer our admiration to the consta
of the heavenly motions themselves, or to the per
cacity and precision with which they have been
ticed by mankind. Nor is this the whole, nor ind
the chief part, of what astronomy teaches. By bri
ing reason to bear upon observation, (the acutest
soning upon the exactest observation,) the astrono
has been able, out of the "mystic dance," and the c
fusion (for such it is) under which the motions of
heavenly bodies present themselves to the eye o
mere gazer upon the skies, to elicit their order
their real paths.

Our knowledge, therefore, of astronomy is adm e, though imperfect; and, amidst the confessed de-derata and desideranda, which impede our investi-ation of the wisdom of the Deity in these the grand-t of his works, there are to be found, in the phe-omena, ascertained circumstances and laws sufficient indicate an intellectual agency in three of its prin-pal operations; viz. in choosing, in determining, in gulating; *choosing*, out of a boundless variety of ppositions which were equally possible, that which beneficial; in *determining*, what, left to itself, had thousand chances against conveniency, for one in favor; in *regulating* subjects, as to quantity and gree, which, by their nature, were unlimited with spect to either. It will be our business to offer, nder each of these heads, a few instances, such as st admit of a popular explication.

I. Amongst proofs of choice, one is, fixing the urce of light and heat in the *centre* of the system. he sun is ignited and luminous; the planets, which ove round him, are cold and dark. There seems to no antecedent necessity for this order. The sun ight have been an opaque mass; some one, or two, more, or any, or all, the planets, globes of fire. here is nothing in the nature of the heavenly bo-es which requires that those which are stationary ould be on fire, that those which move should be ld; for, in fact, comets are bodies on fire, or at least pable of the most intense heat, yet revolve round a ntre: nor does this order obtain between the prima-planets and their secondaries, which are all opaque. hen we consider, therefore, that the sun is one;

that the planets going round it are, at least seven ; t
it is indifferent to their nature which are lumin
and which are opaque : and also in what order, w
respect to each other, these two kinds of bod
are disposed ; we may judge of the improbabil
of the present arrangement taking place by chan

If, by way of accounting for the state in which
find the solar system, it be alleged (and this is
amongst the guesses of those who reject an intellig
Creator) that the planets themselves are only coo
or cooling masses, and were once like the sun, ma
thousand times hotter than red hot iron ; then it
lows, that the sun also himself must be in his p
gress towards growing cold ; which puts an end to
possibility of his having existed, as he is, from eterni
This consequence arises out of the hypothesis w
still more certainty, if we make a part of it, what
philosophers who maintain it have usually taug
that the planets were originally masses of matt
struck off in a state of fusion, from the body of
sun, by the percussion of a comet, or by a shock fr
some other cause with which we are not acquaint
for, if these masses, partaking of the nature and su
stance of the sun's body, have in process of time l
their heat, that body itself, in time likewise, no mat
in how much longer time, must lose its heat also, a
therefore be incapable of an eternal duration in
state in which we see it, either for the time to co
or the time past.

The preference of the present to any other mode
distributing luminous and opaque bodies, I take to

dent. It requires more astronomy than I am able lay before the reader to show, in its particulars, at would be the effect to the system, of a dark body he centre and one of the planets being luminous: I think it manifest, without either plates or calcu-on, first, that supposing the necessary proportion of gnitude between the central and the revolving bo-s to be preserved, the ignited planet would not be ficient to illuminate and warm the rest of the sys-n; secondly, that its light and heat would be im-ted to the other planets much more irregularly than nt and heat are now received from the sun.

*) II. Another thing, in which a choice appears to exercised, and in which, amongst the possibilities of which the choice was to be made, the number those which were wrong bore an infinite proportion the number of those which were right, is in what ometricians call the *axis of rotation*. This matter will endeavor to explain. The earth, it is well own, is not an exact globe, but an oblate spheroid, nething like an orange. Now the axis of rotation, the diameters upon which such a body may be de to turn round, are as many as can be drawn ough its centre to opposite points upon its whole face; but of these axes none are *permanent*, except her its shortest diameter, *i. e.* that which passes ough the heart of the orange from the place where stalk is inserted into it, and which is but one; or longest diameters, at right angles with the former, ich must all terminate in the single circumference ich goes round the thickest part of the orange. The

shortest diameter is that upon which in fact the ea
turns, and it is, as the reader sees, what it ought to
a permanent axis; whereas, had blind chance had
casual impulse, had a stroke or push at random
the earth a-spinning, the odds were infinite but t
they had sent it round upon a wrong axis. And wh
would have been the consequence? The differen
between a permanent axis and another axis is th
When a spheroid in a state of rotatory motion gets
on a permanent axis, it keeps there; it remains stea
and faithful to its position: its poles preserve their
rection to the plane and to the centre of its orbit: b
whilst it turns upon an axis which is *not* permane
(and the number of those we have seen infinitely
ceeds the number of the other,) it is always liable
shift and vacillate from one axis to another, with
corresponding change in the inclination of its po
Therefore, if a planet once set off revolving upon a
other than its shortest, or one of its longest axes,
poles on its surface would keep perpetually changi
and it never would attain a permanent axis of rotati
The effect of this unfixedness, and instability, wou
be, that the equatorial parts of the earth might
come the polar, or the polar the equatorial; to the
ter destruction of plants and animals, which are
capable of interchanging their situations, but are
spectively adapted to their own. As to ourselves,
stead of rejoicing in our temperate zone, and annua
preparing for the moderate vicissitude, or rather t
agreeable succession of seasons, which we experien
and expect, we might come to be locked up in the i

d darkness of the arctic circle, with bodies neither red to its rigors, nor provided with shelter or de-ce against them. Nor would it be much better if trepidation of our pole, taking an opposite course, ould place us under the heats of a vertical sun. But t would fare so ill with the human inhabitant, who live under greater varieties of latitude than any er animal; still more noxious would this transla-n of climate have proved to life in the rest of the ation; and, most perhaps of all, in plants. The bitable earth, and its beautiful variety, might have en destroyed by a simple mischance in the axis of ation.

*) III. All this, however, proceeds upon a suppo-on of the earth having been formed at first an ob-e spheroid. There is another supposition; and per-ps our limited information will not enable us to de-e between them. The second supposition is, that earth, being a mixed mass somewhat fluid, took, it might do, its present form by the joint action of mutual gravitation of its parts and its rotatory mo-n. This, as we have said, is a point in the history he earth, which our observations are not sufficient determine. For a very small depth below the sur-e (but extremely small—less, perhaps, than an ht thousandth part, compared with the depth of the tre,) we find vestiges of ancient fluidity. But this dity must have gone down many hundred times ther than we can penetrate, to enable the earth to e its present oblate form; and whether any traces his kind exist to that depth we are ignorant. Cal-

culations were made a few years ago of the me
density of the earth, by comparing the force of its
traction with the force of attraction of a rock of g
nite, the bulk of which could be ascertained: and t
upshot of the calculation was, that the earth up
an average, through its whole sphere, has twice t
density of granite, or above five times that of wat
Therefore it cannot be a hollow shell, as some ha
formerly supposed; nor can its internal parts be oc
pied by central fire or by water. The solid parts m
greatly exceed the fluid parts: and the probability
that it is a solid mass throughout, composed of su
stances more ponderous the deeper we go. Nevert
less, we may conceive the present face of the earth
have originated from the revolution of a sphere cov
ed by a surface of a compound mixture; the fluid a
solid parts separating, as the surface becomes quiesce
Here then comes in the *moderating* hand of the Cr
tor. If the water had exceeded its present proporti
even but by a trifling quantity, compared with t
whole globe, all the land would have been cover
had there been much less than there is there would n
have been enough to fertilize the continent. Had t
exsiccation been progressive, such as we may suppo
to have been produced by an evaporating heat, h
came it to stop at the point at which we see it? W
did it not stop sooner? why at all? The mandate
the Deity will account for this; nothing else will.

IV. Of centripetal forces. By virtue of t
simplest law that can be imagined, viz. that a bo
continues in the state in which it is, whether of m

on or rest; and, if in motion, goes on in the line in hich it was proceeding, and with the same velocity, *nless* there be some cause for change: by virtue, I y, of this law, it comes to pass (what may appear to a strange consequence) that cases arise in which traction, incessantly drawing a body towards a cene, never brings, nor ever will bring, the body to that ntre, but keep it in eternal circulation round it. If it ere possible to fire off a cannon-ball with a velocity five miles in a second, and the resistance of the air uld be taken away, the cannon-ball would for ever heel round the earth instead of falling down upon it. his is the principle which sustains the heavenly mons. The Deity having appointed this law to mat-r, (than which, as we have said before, no law could more simple,) has turned it to a wonderful account constructing planetary systems.

The actuating cause in these systems is an attracon which varies reciprocally as the square of the disnce; that is, at double the distance, has a quarter of e force; at half the distance, four times the strength; d so on. Now concerning this law of variation, we ve three things to observe; first, that attraction, for y thing we know about it, was just as capable of e law of variation as of another; secondly, that, t of an infinite number of possible laws, those which ere admissible for the purpose of supporting the heanly motions lay within certain narrow limits: third-, that of the admissible laws, or those which come thin the limits prescribed, the law that actually preils is the most beneficial. So far as these propositions can be made out, we may be said, I think, prove *choice* and *regulation:* choice, out of boun less variety; and regulation, of that which, by its ov nature, was, in respect of the property regulated, i different and indefinite.

I. First, then, attraction, for any thing we kno about it, was originally indifferent to all laws of v riation depending upon change of distance, *i. e.* just susceptible of one law as of another. It might ha been the same at all distances; it might have increa ed as the distance increased; or it might have dimi ished with the increase of the distance, yet in t thousand different proportions from the present; might have followed no stated law at all. If attracti be what Cotes, with many other Newtonians, thoug it to be, a primordial property of matter, not depen ent upon, or traceable to, any other material caus then, by the very nature and definition of a primo dial property, it stood indifferent to all laws. If it the agency of something immaterial; then also, f any thing we know of it, it was indifferent to all law If the revolution of bodies round a centre depend up vortices, neither are these limited to one law more th another.

There is, I know, an account given of attractio which should seem, in its very cause, to assign to the law which we find it to observe; and whic therefore, makes that law, a law, not of choice, but necessity; and it is the account which ascribes attra tion to an *emanation* from the attracting body. It probable that the influence of such an emanation w

e proportioned to the spissitude of the rays of which
is composed; which spissitude, supposing the rays
issue in right lines on all sides from a point, will be
eciprocally as the square of the distance. The ma-
ematics of this solution we do not call in question:
e question with us is, whether there be any suffi-
ient reason for believing that attraction is produced
y an emanation. For my part, I am totally at a loss
comprehend how particles streaming *from* a centre
hould draw a body *towards* it. The impulse, if im-
ulse it be, is all the other way. Nor shall we find
ss difficulty in conceiving a conflux of particles, in-
essantly flowing to a centre, and carrying down all
odies along with it, that centre also itself being in a
tate of rapid motion through absolute space; for, by
hat source is the stream fed, or what becomes of the
ccumulation? Add to which, that it seems to imply a
ontrariety of properties, to suppose an ætherial fluid
act, but not to *resist;* powerful enough to carry
own bodies with great force towards a centre, yet,
consistently with the nature of inert matter, power-
ss and perfectly yielding with respect to the motions
hich result from the projectile impulse. By calcula-
ons drawn from ancient notices of eclipses of the
oon, we can prove that, if such a fluid exist at all,
s resistance has had no sensible effect upon the
oon's motion for two thousand five hundred years.
he truth is, that except this one circumstance of the
ariation of the attracting force at different distances
greeing with the variation of the spissitude, there is
o reason whatever to support the hypothesis of an

emanation; and, as it seems to me, almost insuperab reasons against it.

(*) II. Our second proposition is, that whilst th possible laws of variation were infinite, the *admissib* laws, or the laws compatible with the preservation the system, lie within narrow limits. If the attractin force had varied according to any *direct* law of th distance, let it have been what it would, great destru tion and confusion would have taken place. The d rect simple proportion of the distance would, it is tru have produced an ellipse: but the perturbing force would have acted with so much advantage as to b continually changing the dimensions of the ellipse i a manner inconsistent with our terrestrial creatio For instance; if the planet Saturn, so large and so re mote, had attracted the earth, both in proportion to th quantity of matter contained in it, which it does; an also in any proportion to its distance, *i. e.* if it ha pulled the harder for being the further off, (instead the reverse of it,) it would have dragged out of it course the globe which we inhabit, and have perplex ed its motions to a degree incompatible with our se curity, our enjoyments, and probably our existence Of the *inverse* laws, if the centripetal force had chang ed as the cube of the distance, or in any higher pro portion, that is, (for I speak to the unlearned,) if, a double the distance the attractive force had been di minished to an eighth part, or to less than that, th consequence would have been, that the planets, if the once began to approach the sun, would have falle into his body; if they once, though by ever so littl ıcreased their distance from the centre, would foı ver have receded from it. The laws therefore of at-·action, by which a system of revolving bodies could e upholden in their motions, lie within narrow limits, ɔmpared with the possible laws. I much under-rate ıe restriction, when I say that, in a scale of a mile, ıey are confined to an inch. All direct ratios of the istance are excluded, on account of danger from per-ırbing forces: all reciprocal ratios, except what lie ɜneath the cube of the distance, by the demonstrable ɔnsequence, that every the least change of distance ·ould, under the operation of such laws, have been .tal to the repose and order of the system. We do ɔt know, that is, we seldom reflect, how interested e are in this matter. Small irregularities may be en-ıred; but, changes within these limits being allowed ·r, the permanency of our ellipse is a question of life ıd death to our whole sensitive world.

(*) III. That the subsisting law of attraction falls ithin the limits which utility requires, when these nits bear so small a proportion to the range of possi-lities upon which chance might equally have cast it, not, with any appearance of reason, to be accounted r by any other cause than a regulation proceeding om a designing mind. But our next proposition car-ɜs the matter somewhat further. We say, in the third ace, that, out of the different laws which lie within .e limits of admissible laws, the *best* is made choice '; that there are advantages in this particular law hich cannot be demonstrated to belong to any otheı w; and, concerning some of which, it can be demonstrated that they do not belong to any othe

(*) 1. Whilst this law prevails between each pa ticle of matter, the *united* attraction of a sphere com posed of that matter observes the same law. Th property of the law is necessary to render it applicab to a system composed of spheres, but it is a propert which belongs to no other law of attraction that is a missible. The law of variation of the united attractio is in no other case the same as the law of attraction each particle, one case excepted, and that is of the a traction varying directly as the distance; the inconv niency of which law, in other respects, we have a ready noticed.

We may follow this regulation somewhat furthe and still more strikingly perceive that it proceed from a designing mind. A law both admissible a convenient was requisite. In what way is the law the attracting globes obtained? Astronomical observ tions and terrestrial experiments show that the attra tion of the globes of the system is made up of the a traction of their parts; the attraction of each glo being compounded of the attractions of its parts. No the admissible and convenient law which exists, cou not be obtained in a system of bodies gravitating the united gravitation of their parts, unless each pa ticle of matter were attracted by a force varying one particular law, viz. varying inversely as the squa of the distance: for, if the action of the particles according to any other law whatever, the admissib and convenient law, which is adopted, could not obtained. Here then are clearly shown regulation a lesign. A law both admissible and convenient was to e obtained; the mode chosen for obtaining that law vas by making *each* particle of matter act. After this hoice was made, then further attention was to be iven to each particle of matter, and one, and one only articular law of action to be assigned to it. No other ιw would have answered the purpose intended.

(*) 2. All systems must be liable to *perturbations*. ınd therefore, to guard against these perturbations, or ather to guard against their running to destructive engths, is perhaps the strongest evidence of care and oresight that can be given. Now, we are able to demonstrate of our law of attraction, what can be demonstrated of no other, and what qualifies the dangers which arise from cross but unavoidable influences; ıat the action of the parts of our system upon one nother will not cause permanently increasing irregularities, but merely periodical or vibratory ones; that , they will come to a limit, and then go back again. 'his we can demonstrate only of a system in which e following properties concur, viz. that the force hall be inversely, as the square of the distance; the asses of the revolving bodies small, compared with ıat of the body at the centre; the orbits not much clined to one another; and their eccentricity little. n such a system the grand points are secure. The ean distances and periodic times, upon which depend ır temperature, and the regularity of our year, are onstant. The eccentricities, it is true, will still vary; ıt so slowly, and to so small an extent, as to produce inconveniency from fluctuation of temperature and season. The same as to the obliquity of the planes the orbits. For instance, the inclination of the eclipt to the equator will never change above two degree (out of ninety,) and that will require many thousan years in performing.

It has been rightly also remarked, that, if the gre planets, Jupiter and Saturn, had moved in low spheres, their influences would have had much mo effect as to disturbing the planetary motions tha they now have. While they revolve at so great di tances from the rest, they act almost equally on th sun and on the inferior planets; which has nearly th same consequence as not acting at all upon either.

If it be said, that the planets might have been se round the sun in exact circles, in which case, n change of distance from the centre taking place, th law of variation of the attracting power would hav never come in question, one law would have served a well as another; an answer to the scheme may b drawn from the consideration of these same perturb ing forces. The system retaining in other respects i present constitution, though the planets have been a first sent round in exact circular orbits, they could n have kept them; and if the law of attraction had n been what it is, or at least, if the prevailing law ha transgressed the limits above assigned, every evaga tion would have been fatal; the planet once drawn, a drawn it necessarily must have been, out of its cours would have wandered in endless error.

(*) V. What we have seen in the law of the centr petal force, viz. a choice guided by views of utilit ınd a choice of one law out of thousands which night equally have taken place, we see no less in the *igures* of the planetary orbits. It was not enough to ix the law of the centripetal force, though by the visest choice; for even under that law it was still ompetent to the planets to have moved in paths posessing so great a degree of eccentricity, as, in the ourse of every revolution, to be brought very near to he sun, and carried away to immense distances from im. The comets actually move in orbits of this sort; nd, had the planets done so, instead of going round n orbits nearly circular, the change from one extremiy of temperature to another must, in ours at least, ave destroyed every animal and plant upon its surace. Now the distance from the centre at which a lanet sets off, and the absolute force of attraction at hat distance, being fixed, the figure of its orbit, it eing a circle, or nearer to, or further off from a circle, iz. a rounder or a longer oval, depends upon two hings, the velocity with which, and the direction in which, the planet is projected. And these, in order to roduce a right result, must be both brought within ertain narrow limits. One, and only one, velocity, nited with one, and only one, direction, will produce perfect circle. And the velocity must be near to this elocity, and the direction also near to this direction, o produce orbits, such as the planetary orbits are, early circular; that is, ellipses with small eccentriciies. The velocity and the direction must *both* be ight. If the velocity be wrong, no direction will cure he error; if the direction be in any considerable degree oblique, no velocity will produce the orbit re quired. Take for example the attraction of gravity a the surface of the earth. The force of that attractio being what it is, out of all the degrees of velocity swift and slow, with which a ball might be shot of none would answer the purpose of which we ar speaking, but what was nearly that of five miles in second. If it were less than that, the body would n get round at all, but would come to the ground ; if were in any considerable degree more than that, th body would take one of those eccentric courses, thos long ellipses, of which we have noticed the inconven ency. If the velocity reached the rate of seven mile in a second, or went beyond that, the ball would f off from the earth, and never be heard of more. I like manner with respect to the *direction;* out of th innumerable angles in which the ball might be sen off, (I mean angles formed with a line drawn in th centre,) none would serve but what was nearly a righ one ; out of the various directions in which the canno might be pointed, upwards and downwards, every on would fail but what was exactly or nearly horizonta The same thing holds true of the planets : of our ow amongst the rest. We are entitled therefore to ask, an to urge the question, Why did the projectile velocit and projectile direction of the earth happen to be nea ly those which would retain it in a *circular* form Why not one of the infinite number of velocities, on of the infinite number of directions, which woul have made it approach much nearer to, or reced much further from, the sun ?

The planets going round, all in the same direction, nd all nearly in the same plane, afforded to Buffon a ground for asserting, that they had all been shivered rom the sun by the same stroke of a comet, and by hat stroke projected into their present orbits. Now, eside that this is to attribute to chance the fortunate oncurrence of velocity and direction which we have een here noticing, the hypothesis, as I apprehend, is nconsistent with the physical laws by which the heavenly motions are governed. If the planets were struck ff from the surface of the sun they would return to he surface of the sun again. Nor will this difficulty e got rid of by supposing that the same violent blow vhich shattered the sun's surface, and separated large ragments from it, pushed the sun himself out of his lace; for, the consequence of this would be that the un and system of shattered fragments would have a rogressive motion, which, indeed, may possibly be he case with our system; but then each fragment vould, in every revolution, return to the surface of the un again. The hypothesis is also contradicted by the ast difference which subsists between the *diameters* f the planetary orbits. The distance of Saturn from he sun, (to say nothing of the Georgium Sidus,) is early five-and-twenty times that of Mercury; a disparity, which it seems impossible to reconcile with Buffon's scheme. Bodies starting from the same place, vith whatever difference of direction or velocity they et off, could not have been found at these different distances from the centre, still retaining their early circular orbits. They must have been carried to their proper distances before they were projected

To conclude: In astronomy, the great thing is t raise the imagination to the subject, and that ofte times in opposition to the impression made upon th senses. An illusion, for example, must be gotten ov arising from the distance at which we view the hea venly bodies, viz. the apparent *slowness* of their mo tions. The moon shall take some hours in gettin half a yard from a star which it touched. A motio so deliberate we may think easily guided. But wh is the fact? The moon, in fact, is, all this whil driving through the heavens at the rate of cons derably more than two thousand miles in an hou which is more than double that with which a ball shot off from the mouth of a cannon. Yet is this pr digious rapidity as much under government as if th planet proceeded ever so slowly, or were conducted i its course inch by inch. It is also difficult to bring th imagination to conceive (what yet, to judge tolerabl of the matter, is necessary to conceive) how *loose*,

* "If we suppose the matter of the system to be accumulated in th centre by its gravity, *no* mechanical principles, with the assistance of th power of gravity, could separate the vast mass into such parts as the su and planets; and, after carrying them to their different distances, projec ed them in their several directions, preserving still the quality of action an re-action, or the state of the centre of gravity of the system. Such an ex quisite structure of things could only arise from the contrivance and pow erful influences of an intelligent, free, and most potent agent. The sam powers, therefore, which, at present, govern the material universe, and co duct its various motions, are *very different* from those which were nece sary to have produced it from nothing, or to have disposed it in the adm rable form in which it now proceeds."—*Maclaurin's Account of New ton's Philosophy*, p. 407, ed. 3.

'e may so express it, the heavenly bodies are. Enor-ıous globes, held by nothing, confined by nothing, re turned into free and boundless space, each to seek s course by the virtue of an invisible principle; but principle, one, common, and the same in all, and scertainable. To preserve such bodies from being st, from running together in heaps, from hindering ıd distracting one another's motions, in a degree in-ənsistent with any continuing order; *i. e.* to cause .em to form planetary systems, systems that, when rmed, can be upheld, and, most especially, systems :commodated to the organized and sensitive natures hich the planets sustain, as we know to be the case, here alone we can know what the case is, upon our .rth: all this requires an intelligent interposition, be-.use it can be demonstrated concerning it, that it re-ıires an adjustment of force, distance, direction, and ·locity, out of the reach of chance to have produced: ı adjustment, in its view to utility, similar to that hich we see in ten thousand subjects of nature which e nearer to us, but in power, and in the extent of ace through which that power is exerted, stupendous.

But many of the heavenly bodies, as the sun and ɛed stars, are *stationary*. Their rest must be the ef-ɛt of an absence or of an equilibrium of attractions. proves also, that a projectile impulse was originally ven to some of the heavenly bodies, and not to ıers. But further: if attraction act at all distances, ere can only be one quiescent centre of gravity in e universe; and all bodies whatever must be ap-oaching this centre or revolving round it. According

to the first of these suppositions, if the duration of t
world had been long enough to allow of it, all
parts, all the great bodies of which it is compose
must have been gathered together in a heap rou
this point. No changes however which have been o
served, afford us the smallest reason for believing th
either the one supposition or the other is true: a
then it will follow, that attraction itself is controll
or suspended by a superior agent; that there is a po
er above the highest of the powers of material natu
a will which restrains and circumscribes the operatio
of the most extensive.*

* It must here, however, be stated, that many astronomers deny that
of the heavenly bodies are absolutely stationary. Some of the brightes
the fixed stars have certainly small motions; and of the rest the dista
is too great, and the intervals of our observation too short, to enable us
pronounce with certainty that they may not have the same. The moti
in the fixed stars which have been observed, are considered either as p
per to each of them, or as compounded of the motion of our system, and
motions proper to each star. By a comparison of these motions, a mot
in our system is supposed to be discovered. By continuing this analog
other, and to all systems, it is possible to suppose that attraction is u
mited, and that the whole material universe is revolving round some fi
point within its containing sphere or space.

CHAPTER XXIII.

OF THE PERSONALITY OF THE DEITY.

Contrivance, if established, appears to me to prove very thing which we wish to prove. Amongst other ıings, it proves the *personality* of the Deity, as disnguished from what is sometimes called nature, somemes called a principle: which terms, in the mouths f those who use them philosophically, seem to be innded to admit and to express an efficacy, but to exude and to deny a personal agent. Now that which an contrive, which can design, must be a person. 'hese capacities constitute personality, for they imply onsciousness and thought. They require that which an perceive an end or purpose; as well as the power f providing means, and directing them to their end.* 'hey require a centre in which perceptions unite, and om which volitions flow; which is mind. The acts f a mind prove the existence of a mind; and in whatver a mind resides is a person. The seat of intellect ; a person. We have no authority to limit the proerties of mind to any particular corporeal form, or to ny particular circumscription of space. These proerties subsist, in created nature, under a great vaety of sensible forms. Also every animated being has s *sensorium;* that is, a certain portion of space, with-

* Priestley's Letters to a Philosophical Unbeliever, p. 153. ed. 2.

in which perception and volition are exerted. Th
sphere may be enlarged to an indefinite extent; ma
comprehend the universe; and, being so imagine
may serve to furnish us with as good a notion, as w
are capable of forming of the *immensity* of the Divin
Nature, *i. e.* of a Divine Being, infinite, as well in e
sence as in power; yet nevertheless a person.

"No man hath seen God at any time." And this,
believe, makes the great difficulty. Now it is a diff
culty which chiefly arises from our not duly estimatin
the state of our faculties. The Deity, it is true, is th
object of none of our senses: but reflect what limite
capacities animal senses are. Many animals seem
have but one sense, or perhaps two at the most; touc
and taste. Ought such an animal to conclude again
the existence of odors, sounds, and colors? To anoth
species is given the sense of smelling. This is an ad
vance in the knowledge of the powers and properti
of nature: but, if this favored animal should infer fro
its superiority over the class last described, that it pe
ceived every thing which was perceptible in nature
is known to us, though perhaps not suspected by th
animal itself, that it proceeded upon a false and pre
sumptuous estimate of its faculties. To another is add
ed the sense of hearing; which lets in a class of sen
sations entirely unconceived by the animal befor
spoken of; not only distinct, but remote from an
which *it* had ever experienced, and greatly superio
to them. Yet this last animal has no more ground fo
believing that its senses comprehend all things, an
all properties of things, which exist, than might hav

been claimed by the tribes of animals beneath it; for we know that it is still possible to possess another sense, that of sight, which shall disclose to the percipient a new world. This fifth sense makes the animal what the human animal is: but to infer that possibility stops here; that either this fifth sense is the last sense, or that the five comprehend all existence —is just as unwarrantable a conclusion as that which might have been made by any of the different species which possessed fewer, or even by that, if such there be, which possessed only one. The conclusion of the one-sense animal, and the conclusion of the five-sense animal stand upon the same authority. There may be more and other senses than those which we have. There may be senses suited to the perception of the powers, properties, and substance of spirits. These may belong to higher orders of rational agents; for there is not the smallest reason for supposing that we are the highest, or that the scale of creation stops with us.

The great *energies* of nature are known to us only by their effects. The substances which produce them are as much concealed from our senses as the Divine essence itself. *Gravitation*, though constantly present, though constantly exerting its influence, though every where around us, near us, and within us; though diffused throughout all space, and penetrating the texture of all bodies with which we are acquainted, depends, if upon a fluid, upon a fluid which, though both powerful and universal in its operation, is no object of sense to us; if upon any other kind of substance or action, upon a substance and action from which *we* recei no distinguishable impressions. Is it then to be wo dered at that it should, in some measure, be the sam with the Divine nature?

Of this, however, we are certain, that whatever th Deity be, neither the *universe*, nor any part of which we see, can be He. The universe itself merely a collective name: its parts are all which a real; or which are *things*. Now inert matter is out the question; and organized substances include mar of contrivance. But whatever includes marks of co trivance, whatever, in its constitution, testifies desig necessarily carries us to something beyond itself, some other being, to a designer prior to, and out of i self. No animal, for instance, can have contrived i own limbs and senses: can have been the author itself of the design with which they were construct That supposition involves all the absurdity of self-cre tion, *i. e.* of acting without existing. Nothing can God, which is ordered by a wisdom and a will, whic itself is void of; which is indebted for any of its pr perties to contrivance *ab extra*. The *not* having th in his nature which requires the exertion of anoth prior being, (which property is sometimes called se sufficiency, and sometimes self-comprehension,) appe tains to the Deity, as his essential distinction, and moves his nature from that of all things which see: which consideration contains the answer to question that has sometimes been asked, namel Why, since some thing or other must have exist from eternity, may not the present universe be th

›mething? The contrivance perceived in it proves ıat to be impossible. Nothing contrived can, in a rict and proper sense, be eternal, forasmuch as the ›ntriver must have existed before the contrivance.

Wherever we see marks of contrivance we are led ›r its cause to an *intelligent* author. And this tran- tion of the understanding is founded upon uniform ‹perience. We see intelligence constantly contriving; ıat is, we see intelligence constantly producing ef- ·cts, marked and distinguished by certain properties; ›t certain particular properties, but by a kind and ass of properties, such as relation to an end, relation ‹ parts to one another, and to a common purpose. /e see, wherever we are witnesses to the actual for- ıation of things, nothing except intelligence producing fects so marked and distinguished. Furnished with ıis experience, we view the productions of nature. /e observe *them* also marked and distinguished in ıe same manner. We wish to account for their origin. ur experience suggests a cause perfectly adequate to ıis account. No experience, no single instance or ‹ample, can be offered in favor of any other. In this ıuse, therefore, we ought to rest: in this cause the ›mmon sense of mankind has, in fact, rested, because agrees with that, which, in all cases, is the founda- ›n of knowledge,—the undeviating course of their ‹perience. The reasoning is the same as that by hich we conclude any ancient appearances to have ›en the effects of volcanoes or inundations; namely, ›cause they resemble the effects which fire and water ·oduce before our eyes; and because we have never

known these effects to result from any other operatio
And this resemblance may subsist in so many circu
stances as not to leave us under the smallest dou
in forming our opinion. Men are not deceived by th
reasoning; for whenever it happens, as it sometim
does happen, that the truth comes to be known by d
rect information, it turns out to be what was expecte
In like manner and upon the same foundation, (whi
in truth is that of experience,) we conclude that t
works of nature proceed from intelligence and desig
because, in the properties of relation to a purpose, su
serviency to a use, they resemble what intelligen
and design are constantly producing, and what n
thing except intelligence and design ever produce
all. Of every argument which would raise a que
tion as to the safety of this reasoning, it may be o
served, that if such argument be listened to, it leads
the inference, not only that the present order of natu
is insufficient to prove the existence of an intellige
Creator, but that no imaginable order would be suf
cient to prove it; that *no* contrivance, were it ever
mechanical, ever so precise, ever so clear, ever so pe
fectly like those which we ourselves employ, wou
support this conclusion—a doctrine to which I co
ceive no sound mind can assent.

The force, however, of the reasoning is sometim
sunk by our taking up with mere names. We hav
already noticed,* and we must here notice again, th
misapplication of the term "law," and the mistak

* Ch. i. sect. vii.

concerning the idea which that term expresses in physics, whenever such idea is made to take the place of power, and still more of an intelligent power, and, as such, to be assigned for the cause of any thing, or any property of any thing that exists. This is what we are secretly apt to do, when we speak of organized bodies, (plants, for instance, or animals,) owing their production, their form, their growth, their qualities, their beauty, their use, to any law or laws of nature; and when we are contented to sit down with that answer to our inquiries concerning them. I say once more, that it is a perversion of language to assign any law as the efficient, operative cause of any thing. A law pre-supposes an agent, for it only is the mode according to which an agent proceeds; it implies a power, for it is the order according to which that power acts. Without this agent, without this power, which are both distinct from itself, the "law" does nothing; is nothing.

What has been said concerning "law," holds true of *mechanism*. Mechanism is not itself power. Mechanism without power can do nothing. Let a watch be contrived and constructed ever so ingeniously; be its parts ever so many, ever so complicated, ever so finely wrought or artificially put together, it cannot go without a weight or spring, *i. e.* without a force independent of, and ulterior to, its mechanism. The spring acting at the centre, will produce different motions and different results, according to the variety of the intermediate mechanism. One and the self-same spring, acting in one and the same manner, viz. by

simply expanding itself, may be the cause of a hu
dred different and all useful movements, if a hundr
different and well-devised sets of wheels be placed b
tween it and the final effect: *e. g.* may point out t
hour of the day, the day of the month, the age of t
moon, the position of the planets, the cycle of the yea
and many other serviceable notices; and these mov
ments may fulfil their purposes with more or less pe
fection, according as the mechanism is better or wor
contrived, or better or worse executed, or in a better
worse state of repair: *but in all cases it is necessa
that the spring act at the centre.* The course of o
reasoning upon such a subject would be this: By i
specting the watch, even when standing still, we g
a proof of contrivance, and of a contriving min
having been employed about it. In the form and o
vious relations of its parts we see enough to convin
us of this. If we pull the works in pieces, for the pu
pose of a closer examination, we are still more ful
convinced. But when we see the watch *going* w
see proof of another point, viz. that there is a pow
somewhere, and somehow or other applied to it:
power in action;—that there is more in the subje
than the mere wheels of the machine;—that there
a secret spring, or a gravitating plummet;—in a wor
that there is force and energy as well as mechanis

So, then, the watch in motion establishes to t
observer two conclusions: One,—that thought, cont
vance, and design, have been employed in the formin
proportioning, and arranging of its parts; and th
whoever or whatever he be, or were, such a contriv

here is, or was: The other, that force or power, distinct from mechanism, is at this present time acting pon it. If I saw a hand-mill even at rest, I should ee contrivance: but if I saw it grinding, I should be ssured that a hand was at the windlass, though in nother room. It is the same in nature. In the works f nature we trace mechanism: and this alone proves ontrivance: but living, active, moving, productive ature, proves also the exertion of a power at the cene; for, wherever the power resides may be denomiated the centre.

The intervention and disposition of what are called "*second causes*" fall under the same observation. 'his disposition is or is not mechanism, according as e can or cannot trace it by our senses and means of xamination. That is all the difference there is; and is a difference which respects our faculties, not the iings themselves. Now where the order of second uses is mechanical, what is here said of mechanism rictly applies to it. But it would be always mechanm (natural chemistry, for instance, would be meianism) if our senses were acute enough to descry . Neither mechanism, therefore, in the works of ature, nor the intervention of what are called second uses, (for I think that they are the same thing,) exses the necessity of an agent distinct from both.

If, in tracing these causes, it be said that we find rtain general properties of matter which have noing in them that bespeaks intelligence, I answer at still the *managing* of these properties, the pointg and directing them to the uses which we see made

of them, demands intelligence in the highest degre
For example: suppose animal secretions to be electi
attractions, and that such and such attractions unive
sally belong to such and such substances—in all whi
there is no intellect concerned; still the choice a
collocation of these substances, the fixing upon rig
substances, and disposing them in right places, mu
be an act of intelligence. What mischief would follo
were there a single transposition of the secretory c
gans; a single mistake in arranging the glands whi
compose them!

There may be many second causes, and ma
courses of second causes, one behind another, betwe
what we observe of nature, and the Deity: but the
must be intelligence somewhere: there must be mo
in nature than what we see; and, amongst the thin
unseen, there must be an intelligent, designing auth
The philosopher beholds with astonishment the pr
duction of things around him. Unconscious partic
of matter take their stations, and severally ran
themselves in an order, so as to become collective
plants or animals, *i. e.* organized bodies, with pa
bearing strict and evident relation to one another, a
to the utility of the whole: and it should seem th
these particles could not move in any other way th
as they do; for they testify not the smallest sign
choice, or liberty, or discretion. There may be par
cular intelligent beings, guiding these motions in ea
case; or they may be the result of trains of mecha
cal dispositions, fixed beforehand by an intellige
appointment, and kept in action by a power at th

entre. But, in either case, there must be intelligence.

The minds of most men are fond of what they call a *principle*, and of the appearance of simplicity, in accounting for phænomena. Yet this principle, this simplicity, resides merely in the *name*; which name, after all, comprises, perhaps, under it a diversified, multifarious, or progressive operation, distinguishable into parts. The power in organized bodies, of producing bodies like themselves, is one of these principles. Give a philosopher this, and he can get on. But he does not reflect what this mode of production, this principle (if such he choose to call it) requires; how much it presupposes; what an apparatus of instruments, some of which are strictly mechanical, is necessary to its success; what a train it includes of operations and changes, one succeeding another, one related to another, one ministering to another; all advancing, by intermediate, and, frequently, by sensible steps, to their ultimate result! Yet, because the whole of this complicated action is wrapped up in a single term, *generation*, we are to set it down as an elementary principle; and to suppose, that when we have resolved the things which we see into this principle, we have sufficiently accounted for their origin, without the necessity of a designing, intelligent Creator. The truth is, generation is not a principle, but a *process*. We might as well call the casting of metals a principle; we might, so far as appears to me, as well call spinning and weaving principles: and then, referring the texture of cloths, the fabric of muslins and calicoes, the patterns of diapers and damasks, to these, as principles, pretend to dispense with intention, thougl and contrivance, on the part of the artist; or to di pense, indeed, with the necessity of any artist at a either in the manufacturing of the article, or in t fabrication of the machinery by which the manufa ture was carried on.

And, after all, how, or in what sense is it true, th animals produce their *like?* A butterfly, with a pı boscis instead of a mouth, with four wings and s legs, produces a hairy caterpillar, with jaws and teet and fourteen feet. A frog produces a tadpole. A bla beetle, with gauze wings, and a crusty covering, pı duces a white, smooth, soft worm; an ephemeron fl a cod-bait maggot. These, by a progress through d ferent stages of life, and action, and enjoyment, (an in each state, provided with implements and orga appropriated to the temporary nature which they bea arrive at last at the form and fashion of the pare animal. But all this is process, not principle; a proves, moreover, that the property of animated bodi of producing their like, belongs to them, not as a p mordial property, not by any blind necessity in t nature of things, but as the effect of economy, wisdo and design; because the property itself assumes div sities, and submits to deviations dictated by intelli ble utilities, and serving distinct purposes of anim happiness.

The opinion, which would consider "generatior as a *principle* in nature; and which would assign tl principle as the cause, or endeavor to satisfy our min with such a cause, of the existence of organized l ies; is confuted, in my judgement, not only by every nark of contrivance discoverable in those bodies, for which it gives us no contriver, offers no account whatver; but also by the further consideration, that things enerated possess a clear relation to things *not* geneated. If it were merely one part of a generated body earing a relation to another part of the same body; s the mouth of an animal to the throat, the throat to he stomach, the stomach to the intestines, those to the ecruiting of the blood, and, by means of the blood, to he nourishment of the whole frame: or if it were nly one generated body bearing a relation to another enerated body; as the sexes of the same species to ach other, animals of prey to their prey, herbivorous nd granivorous animals to the plants or seeds upon which they feed, it might be contended, that the whole of this correspondency was attributable to geneation, the common origin from which these substances roceeded. But what shall we say to agreements which xist between things generated and things *not generated?* Can it be doubted, was it ever doubted, but hat the *lungs* of animals bear a relation to the *air*, as a permanently elastic fluid? They act in it and by it; hey cannot act without it. Now, if generationproluced the animal, it did not produce the air: yet their roperties correspond. The *eye* is made for *light*, and ight for the eye. The eye would be of no use without light, and light perhaps of little without eyes; yet one is produced by generation, the other not. The *ear* lepends upon *undulations* of air. Here are two sets of motions; first, of the pulses of the air; secondly,

of the drum, bones, and nerves of the ear; sets of mo-
tions bearing an evident reference to each other: ye
the one, and the apparatus for the one, produced by
the intervention of generation; the other altogethe
independent of it.

If it be said, that the air, the light, the elements, th
world itself, is *generated;* I answer, that I do not com-
prehend the proposition. If the term mean any thing
similar to what it means when applied to plants o
animals, the proposition is certainly without proof
and, I think, draws as near to absurdity as any propo-
sition can do which does not include a contradictio
in its terms. I am at a loss to conceive how the forma-
tion of the world can be compared to the generation o
an animal. If the term generation signify somethin
quite different from what it signifies on ordinary occa-
sions, it may, by the same latitude, signify any thing
In which case, a word or phrase taken from the lan-
guage of Otaheite would convey as much theory con-
cerning the origin of the universe, as it does to talk o
its being generated.

We know a cause (intelligence) adequate to the ap-
pearances which we wish to account for: we hav
this cause continually producing similar appearances
yet rejecting this cause, the sufficiency of which we
know, and the action of which is constantly before ou
eyes, we are invited to resort to suppositions destitut
of a single fact for their support, and confirmed by no
analogy with which we are acquainted. Were it ne-
cessary to inquire into the *motives* of men's opinions
I mean their motives separate from their arguments

I should almost suspect, that, because the proof of a Deity drawn from the constitution of nature is not only popular, but vulgar, (which may arise from the cogency of the proof, and be indeed its highest recommendation,) and because it is a species almost of *puerility* to take up with it; for these reasons, minds which are habitually in search of invention and originality, feel a resistless inclination to strike off into other solutions and other expositions. The truth is, that many minds are not so indisposed to any thing which can be offered to them as they are to the *flatness* of being content with common reasons: and, what is most to be lamented, minds conscious of superiority are the most liable to this repugnancy.

The "suppositions" here alluded to all agree in one character: they all endeavor to dispense with the necessity in nature of a particular, personal intelligence; that is to say, with the exertion of an intending, contriving mind, in the structure and formation of the organized constitutions which the world contains. They would resolve all productions into *unconscious* energies, of a like kind, in that respect, with attraction, magnetism, electricity, &c. without any thing further.

In this, the old system of atheism and the new agree. And I much doubt whether the new schemes have advanced any thing upon the old, or done more than changed the terms of the nomenclature. For instance, I could never see the difference between the antiquated system of atoms, and Buffon's organic molecules. This philosopher, having made a planet by knocking off from the sun a piece of melted glass, in consequence of the stroke of a comet; and having set it in motion, by the same stroke, both round its own axis and the sun; finds his next difficulty to be how to bring plants and animals upon it. In order to solve this difficulty we are to suppose the universe replenished with particles, endowed with life, but without organization or senses of their own; and endowed also with a tendency to marshal themselves into organized forms. The concourse of these particles, by virtue of this tendency, but without intelligence, will or direction, (for I do not find that any of these qualities are ascribed to them,) has produced the living forms which we now see.

Very few of the conjectures which philosophers hazard upon these subjects have more of pretension in them than the challenging you to show the direct impossibility of the hypothesis. In the present exampl there seemed to be a positive objection to the whol scheme upon the very face of it; which was that, i the case were as here represented, *new* combination ought to be perpetually taking place; new plants and animals, or organized bodies which were neither ought to be starting up before our eyes every day. Fo this, however, our philosopher has an answer. Whils so many forms of plants and animals are already in existence, and consequently, so many "interna moulds," as he calls them, are prepared and at hand the organic particles run into these moulds, and ar employed in supplying an accession of substance t them, as well for their growth as for their propagation By which means things keep their ancient course

But, says the same philosopher, should any general loss or destruction of the present constitution of organized bodies take place, the particles, for want of "moulds" into which they might enter, would run into different combinations, and replenish the waste with new species of organized substances.

Is there any history to countenance this notion? Is it known that any destruction has been so repaired? any desert thus re-peopled?

So far as I remember, the only natural appearance mentioned by our author, by way of fact whereon to build his hypothesis, is the formation of *worms* in the intestines of animals, which is here ascribed to the coalition of superabundant organic particles floating about in the first passages; and which have combined themselves into these simple animal forms for want of internal moulds, or of vacancies in those moulds, into which they might be received. The thing referred to is rather a species of facts, than a single fact; as some other cases may, with equal reason, be included under it. But to make it a fact at all, or in any sort, applicable to the question, we must begin with asserting an *equivocal* generation, contrary to analogy, and without necessity: contrary to an analogy which accompanies us to the very limits of our knowledge or inquiries; for wherever, either in plants or animals, we are able to examine the subject, we find procreation from a parent form: without necessity; for I apprehend that it is seldom difficult to suggest methods by which the eggs, or spawn, or yet invisible rudiments of these vermin, may have obtained a passage into the cavities in which they ar found.* Add to this, that their *constancy to their species* which, I believe, is as regular in these as in the othe vermes, decides the question against our philosopher if, in truth, any question remained upon the subject

Lastly; these wonder-working instruments, these "internal moulds," what are they after all? wha when examined, but a name without a signification unintelligible, if not self-contradictory; at the best differing in nothing from the "essential forms" of th Greek philosophy? One short sentence of Buffon's work exhibits his scheme as follows: "When this nu tritious and prolific matter, which is diffused through out all nature, passes through the *internal mould* o an animal or vegetable, and finds a proper matrix o receptacle, it gives rise to an animal or vegetable of th same species." Does any reader annex a meaning t the expression "internal mould," in this sentence Ought it then to be said, that though we have littl notion of an internal mould, we have not much mor of a designing mind? The very contrary of this as sertion is the truth. When we speak of an artificer o an architect, we talk of what is comprehensible to ou understanding and familiar to our experience. W use no other terms than what refer us for their mean ing to our consciousness and observation; what ex press the constant objects of both: whereas names lik

* I trust I may be excused for not citing, as another fact which is t confirm the hypothesis, a grave assertion of this writer, that the branche of trees upon which the stag feeds break out again in his horns. Suc *facts* merit no discussion.

hat we have mentioned refer us to nothing; excite no dea; convey a sound to the ear, but I think do no more.

Another system which has lately been brought for-vard, and with much ingenuity, is that of *appetencies.* Che principle and the short account of the theory is his: Pieces of soft, ductile matter, being endued vith propensities or appetencies for particular actions, vould, by continual endeavors, carried on through a ong series of generations, work themselves gradually nto suitable forms; and at length acquire, though erhaps by obscure and almost imperceptible im-rovements, an organization fitted to the action which heir respective propensities led them to exert. A iece of animated matter, for example, that was en-lued with a propensity to *fly*, though ever so shape-ess, though no other we will suppose than a round all to begin with, would, in a course of ages, if not in a million of years, perhaps in a hundred millions of ears (for our theorists, having eternity to dispose of, re never sparing in time) acquire *wings*. The same endency to loco-motion in an aquatic animal, or ather in an animated lump, which might happen to e surrounded by water, would end in the production f *fins;* in a living substance, confined to the solid arth, would put out *legs* and *feet;* or, if it took a dif-erent turn, would break the body into ringlets, and onclude by *crawling* upon the ground.

Although I have introduced the mention of this heory into this place, I am unwilling to give to it the ame of an *atheistic* scheme, for two reasons: first, ecause, so far as I am able to understand it, the origi-

nal propensities and the numberless varieties of the
(so different, in this respect, from the laws of m
chanical nature, which are few and simple) are in th
plan itself, attributed to the ordination and appoin
ment of an intelligent and designing Creator: secondl
because, likewise, that large postulatum, which is a
along assumed and pre-supposed, the faculty in livin
bodies of producing other bodies organized like then
selves, seems to be referred to the same cause;
least is not attempted to be accounted for by any othe
In one important respect, however, the theory befo
us coincides with atheistic systems, viz. in that, in th
formation of plants and animals, in the structure an
use of their parts, it does away final causes. Instea
of the parts of a plant or animal, or the particul
structure of the parts, having been intended for th
action or the use to which we see them applied; a
cording to this theory, they have themselves grow
out of that action, sprung from that use. The theo
therefore dispenses with that, which we insist upo
the necessity, in each particular case, of an intelliger
designing mind, for the contriving and determinin
of the forms which organized bodies bear. Give o
philosopher these appetencies; give him a portion
living irritable matter (a nerve, or the clipping of
nerve) to work upon: give also to his incipient
progressive forms the power, in every stage, of the
alteration, of propagating their like; and, if he is to b
believed, he could replenish the world with all th
vegetable and animal productions which we at prese
see in it.

The scheme under consideration is open to the same objection with other conjectures of a similar tendency, viz. a total defect of evidence. No changes, like those which the theory requires, have ever been observed. All the changes in Ovid's Metamorphoses might have been effected by these appetencies, if the theory were true; yet not an example, nor the pretence of an example, is offered of a single change being known to have taken place. Nor is the order of generation obedient to the principle upon which this theory is built. The mammæ* of the male have not vanished by inusitation; *nec curtorum, per multa sæcula, Judæorum propagini deest præputium.* It is easy to say, and it has been said, that the alterative process is too slow to be perceived; that it has been carried on through tracts of immeasurable time; and that the present order of things is the result of a graduation of which no human records can trace the steps. It is easy to say this; and yet it is still true, that the hypothesis remains destitute of evidence.

The *analogies* which have been alleged are of the following kind: The *bunch* of a camel is said to be no other than the effect of carrying burdens; a service in which the species has been employed from the most ancient times of the world. The first race, by the daily loading of the back, would probably find a small gru-

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* I confess myself totally at a loss to guess at the reason, either final or efficient, for this part of the animal frame; unless there be some foundation for an opinion of which I draw the hint from a paper of Mr. Everard Home, (Phil. Transact. 1799, Pt. 2,) viz. that the mammæ of the fœtus may be formed before the sex is determined.

mous tumor to be formed in the flesh of that par The next progeny would bring this tumor into th world with them. The life to which they were des tined would increase it. The cause which first gene rated the tubercle being continued, it would go on through every succession, to augment its size, till attained the form and the bulk under which it no appears. This may serve for one instance: anothe and that also of the passive sort, is taken from certai species of birds. Birds of the *crane* kind, as the cran itself, the heron, bittern, stork, have, in general, the thighs bare of feathers. This privation is accounte for from the habit of wading in water, and from th effect of that element to check the growth of feathe upon these parts; in consequence of which, the healt and vegetation of the feathers declined through eac generation of the animal; the tender down, expose to cold and wetness, became weak, and thin, and rar till the deterioration ended in the result which we se of absolute nakedness. I will mention a third instanc because it is drawn from an active habit, as the tw last were from passive habits; and that is the *pou* of the pelican. The description which naturalists gi of this organ is as follows: "From the lower edge the under chap, hangs a bag, reaching from the who length of the bill to the neck, which is said to be c pable of containing fifteen quarts of water. This ba the bird has a power of wrinkling up into the hollo of the under chap. When the bag is empty it is n seen; but when the bird has fished with success, it incredible to what an extent it is often dilated. Th rst thing the pelican does in fishing is to fill the bag; nd then it returns to digest its burden at leisure. The ird preys upon the large fishes, and hides them by ozens in its pouch. When the bill is opened to its idest extent, a person may run his head into the rd's mouth, and conceal it in this monstrous pouch, ius adapted for very singular purposes."* Now this xtraordinary conformation is nothing more, say our hilosophers, than the result of habit; not of the habit effort of a single pelican, or of a single race of pelians, but of a habit perpetuated through a long series generations. The pelican soon found the conveniency of reserving in its mouth, when its appetite was utted, the remainder of its prey, which is fish. The ilness produced by this attempt, of course stretched ie skin which lies between the under chaps, as being ie most yielding part of the mouth. Every distention icreased the cavity. The original bird, and many generations which succeeded him, might find difficulty iough in making the pouch answer this purpose: ut future pelicans, entering upon life with a pouch erived from their progenitors, of considerable capaty, would more readily accelerate its advance to perction, by frequently pressing down the sac with the eight of fish which it might now be made to contain.

These, or of this kind, are the analogies relied upon. ow, in the first place, the instances themselves are nauthenticated by testimony; and in theory, to say

* Goldsmith, vol. 6, p. 52.

the least of them, open to great objections. Who ev read of camels without bunches, or with bunches le than those with which they are at present usuall formed? A bunch, not unlike the camel's, is foun between the shoulders of the buffalo; of the origin which it is impossible to give the account here give In the second example: Why should the applicati of water, which appears to promote and thicken t growth of feathers upon the bodies and breasts geese, and swans, and other water-fowls, have dive ed of this covering the thighs of cranes? The thi instance, which appears to me as plausible as any th can be produced, has this against it, that it is a sing larity restricted to the species; whereas, if it had i commencement in the cause and manner which ha been assigned, the like conformation might be expe ed to take place in other birds which feed upon fis How comes it to pass, that the pelican alone was t inventress, and her descendants the only inheritors, this curious resource?

But it is the less necessary to controvert the insta ces themselves, as it is a straining of analogy beyo all limits of reason and credibility, to assert that bir and beasts, and fish, with all their variety and co plexity of organization, have been brought into the forms, and distinguished into their several kinds a natures, by the same process (even if that proce could be demonstrated, or had it ever been actual noticed,) as might seem to serve for the gradual ge ration of a camel's bunch or a pelican's pouch.

The solution, when applied to the works of natu *nerally*, is contradicted by many of the phænomena, ıd totally inadequate to others. The *ligaments* or rictures, by which the tendons are tied down at the ıgles of the joints, could, by no possibility, be formed y the motion or exercise of the tendons themselves; y an appetency exciting these parts into action; or y any tendency arising therefrom. The tendency is l the other way: the *conatus* in constant opposition them. Length of time does not help the case at all, ıt the reverse. The *valves* also in the blood-vessels ɔuld never be formed in the manner which our theost proposes. The blood, in its right and natural ɔurse, has no tendency to form them. When obstructl or refluent, it has the contrary. These parts could ɔt grow out of their use, though they had eternity to row in.

The *senses* of animals appear to me altogether inıpable of receiving the explanation of their origin hich this theory affords. Including under the word sense" the organ and the perception, we have no ac ɔunt of either. How will our philosopher get at *ision*, or make an eye? How should the blind animal ffect sight, of which blind animals we know have either conception nor desire? Affecting it, by what peration of its will, by what endeavor to see, could it ɔ determine the fluids of its body as to inchoate the ɔrmation of an eye? or suppose the eye formed, would ıe perception follow? The same of the other senses. ınd this objection holds its force, ascribe what you rill to the hand of time, to the power of habit, to ıanges too slow to be observed by man, or brought within any comparison which he is able to make past things with the present; concede what you plea to these arbitrary and unattested suppositions, ho will they help you? Here is no inception. No lav no course, no powers of nature which prevail at prese nor any analogous to these, would give commen ment to a new sense. And it is in vain to inqu how that might proceed which could never *begin.*

I think the senses to be the most inconsistent wi the hypothesis before us, of any part of the anim frame. But other parts are sufficiently so. The sol tion does not apply to the parts of animals whi have little in them of motion. If we could suppo joints and muscles to be gradually formed by acti and exercise, what action or exercise could form skull, and fill it with brains? No effort of the anim could determine the clothing of its skin. What *con tus* could give prickles to the porcupine or hedgeho or to the sheep its fleece?

In the last place: What do these appetencies me when applied to plants? I am not able to give a sig fication to the term which can be transferred from a mals to plants; or which is common to both. Yet no less successful organization is found in plants, th what obtains in animals. A solution is wanted for o as well as the other.

Upon the whole, after all the schemes and struggl of a reluctant philosophy, the necessary resort is to Deity. The marks of *design* are too strong to be gott over. Design must have had a designer. That desig er must have been a person. That person is God.

CHAPTER XXIV.

N THE NATURAL ATTRIBUTES OF THE DEITY.

It is an immense conclusion, that there is a God; a rceiving, intelligent, designing Being; at the head creation, and from whose will it proceeded. The *tributes* of such a Being, suppose his reality to be oved, must be adequate to the magnitude, extent, d multiplicity of his operations: which are not only st beyond comparison with those performed by any her power; but, so far as respects our conceptions of em, infinite, because they are unlimited on all sides.

Yet the contemplation of a nature so exalted, how-er surely we arrive at the proof of its existence, erwhelms our faculties. The mind feels its powers ık under the subject. One consequence of which is, at from painful abstraction the thoughts seek relief sensible images. Whence may be deduced the cient, and almost universal propensity to idolatrous bstitutions. They are the resources of a laboring agination. False religions usually fall in with the tural propensity; true religions, or such as have rived themselves from the true, resist it.

It is one of the advantages of the revelations which e acknowledge, that, whilst they reject idolatry with many pernicious accompaniments, they introduce e Deity to human apprehension, under an idea more rsonal, more determinate, more within its compass, an the theology of nature can do. And this they do by representing him exclusively under the relation i which he stands to ourselves; and, for the most par under some precise character, resulting from that rela tion, or from the history of his providences: whic method suits the span of our intellects much bette than the universality which enters into the idea c God, as deduced from the views of nature. Whe therefore, these representations are well founded i point of authority, (for all depends upon that,) the afford a condescension to the state of our faculties, which they, who have most reflected on the subjec will be the first to acknowledge the want and th value.

Nevertheless, if we be careful to imitate the docu ments of our religion, by confining our explanatio to what concerns ourselves, and do not affect mo precision in our ideas than the subject allows of, th several terms which are employed to denote the attr butes of the Deity may be made, even in natural r ligion, to bear a sense consistent with truth and re son, and not surpassing our comprehension.

These terms are,—Omnipotence, omniscience, or nipresence, eternity, self-existence, necessary existenc spirituality.

"Omnipotence," "omniscience," "infinite" powe "infinite" knowledge, are *superlatives;* expressi our conception of these attributes in the strongest a most elevated terms which language supplies. W ascribe power to the Deity under the name of "om potence," the strict and correct conclusion being, th a power which could create such a world as this ıst be, beyond all comparison, greater than any ıich we experience in ourselves, than any which we serve in other visible agents: greater also than any ıich we can want, for our individual protection and servation, in the Being upon whom we depend. It a power, likewise, to which we are not authorized, our observation or knowledge, to assign any limits space or duration.

Very much of the same sort of remark is applicable the term "omniscience," infinite knowledge, or infie wisdom. In strictness of language, there is a difence between knowledge and wisdom; wisdom alys supposing action, and action directed by it. With pect to the first, viz. *knowledge*, the Creator must ow, intimately, the constitution and properties of the ngs which he created: which seems also to imply oreknowledge of their action upon one another, and their changes; at least, so far as the same result m trains of physical and necessary causes. His omcience also, as far as respects things present, is decible from his natures, an intelligent being, joined th the extent, or rather the universality of his opeions. Where he acts, he is: and where he is, he rceives. The *wisdom* of the Deity, as testified in works of creation, surpasses all idea we have of sdom, drawn from the highest intellectual operans of the highest class of intelligent beings with ıom we are acquainted; and, which is of the chief portance to us, whatever be its compass or extent, ıich it is evidently impossible that we should be le to determine, it must be adequate to the conduct

of that order of things under which we live. And
is enough. It is of very inferior consequence by w
terms we express our notion, or rather our admirat
of this attribute. The terms, which the piety and
usage of language have rendered habitual to us, n
be as proper as any other. We can trace this attril
much beyond what is necessary for any conclusion
which we have occasion to apply it. The degre
knowledge and power requisite for the formation
created nature cannot, with respect to us, be dis
guished from infinite.

The divine "omnipresence" stands, in natural th
logy, upon this foundation:—In every part and pl
of the universe with which we are acquainted, we p
ceive the exertion of a power, which we believe, m
diately or immediately, to proceed from the Deity.
instance: in what part or point of space that has e
been explored, do we not discover attraction? In w
regions do we not find light? In what accessible p
tion of our globe do we not meet with gravity, m
netism, electricity: together with the properties a
and powers of organized substances, of vegetable
of animated nature? Nay, further, we may ask, W
kingdom is there of nature, what corner of space,
which there is any thing that can be examined by
where we do not fall upon contrivance and desig
The only reflection perhaps which arises in our mi
from this view of the world around us is, that
laws of nature every where prevail; that they
uniform and universal. But what do you mean by
laws of nature, or by any law? Effects are produc

power, not by laws. A law cannot execute itself. law refers us to an agent. Now an agency so gene-l, as that we cannot discover its absence, or assign e place in which some effect of its continued energy not found, may, in popular language at least, and, rhaps, without much deviation from philosophical ictness, be called universal: and, with not quite the me, but with no inconsiderable propriety, the per-n, or Being, in whom that power resides, or from hom it is derived, may be taken to be *omnipresent.* e who upholds all things by his power, may be said be every where present.

This is called a virtual presence. There is also what etaphysicians denominate an essential ubiquity; and hich idea the language of Scripture seems to favor: t the former, I think, goes as far as natural theology rries us.

"Eternity" is a negative idea, clothed with a post-e name. It supposes, in that to which it is applied, present existence; and is the negation of a beginning an end of that existence. As applied to the Deity, it s not been controverted by those who acknowledge Deity at all. Most assuredly there never was a time which nothing existed, because that condition must ve continued. The universal *blank* must have re-ined; nothing could rise up out of it; nothing could er have existed since; nothing could exist now. In ictness, however, we have no concern with dura-n prior to that of the visible world. Upon this article refore of theology, it is sufficient to know that the ntriver necessarily existed before the contrivance.

"Self-existence" is another negative idea, viz. negation of a preceding cause, as of a progenito maker, an author, a creator.

"Necessary existence" means demonstrable istence.

"Spirituality" expresses an idea made up of a gative part and of a positive part. The negative consists in the exclusion of some of the known perties of matter, especially of solidity, of the *inertiæ*, and of gravitation. The positive part co prises perception, thought, will, power, *action*, which last term is meant the origination of motic the quality, perhaps, in which resides the essent superiority of spirit over matter, "which cannot mo unless it be moved; and cannot but move, when pelled by another."* I apprehend that there can no difficulty in applying to the Deity both parts this idea.

CHAPTER XXV.

OF THE UNITY OF THE DEITY.

Of the "Unity of the Deity," the proof is, the *u formity* of plan observable in the universe. The u

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* Bishop Wilkins's Principles of Natural Religion, p. 106

erse itself is a system; each part either depending
pon other parts, or being connected with other parts
y some common law of motion, or by the presence of
ome common substance. One principle of gravitation
auses a stone to drop towards the earth, and the
oon to wheel round it. One law of attraction carries
ll the different planets about the sun. This philoso-
hers demonstrate. There are also other points of
greement amongst them, which may be considered as
arks of the identity of their origin and of their in-
elligent Author. In all are found the conveniency and
ability derived from gravitation. They all experience
icissitudes of days and nights, and changes of sea-
on. They all, at least Jupiter, Mars and Venus, have
e same advantages from their atmosphere as we
ave. In all the planets, the axes of rotation are per-
anent. Nothing is more probable than that the same
tracting influence, acting according to the same rule,
aches to the fixed stars: but, if this be only proba-
e, another thing is certain, viz. that the same element
light does. The light from a fixed star affects our
es in the same manner, is refracted and reflected ac-
ording to the same laws, as the light of a candle.
he velocity of the light of the fixed stars is also the
me as the velocity of the light of the sun, reflected
om the satellites of Jupiter. The heat of the sun, in
nd, differs nothing from the heat of a coal fire.

In our own globe the case is clearer. New countries
e continually discovered, but the old laws of nature
e always found in them; new plants, perhaps, or
imals, but always in company with plants and ani-

mals which we already know; and always possessi many of the same general properties. We never amongst such original, or totally different, modes existence, as to indicate that we are come into t province of a different Creator, or under the directi of a different will. In truth, the same order of thin attends us wherever we go. The elements act up one another, electricity operates, the tides rise and fa the magnetic needle elects its position, in one region the earth and sea, as well as in another. One atm phere invests all parts of the globe, and connects a one sun illuminates, one moon exerts its specific traction upon all parts. If there be a variety in na ral effects, as, *e. g.* in the tides of different seas, th very variety is the result of the same cause, acti under different circumstances. In many cases this proved; in all, is probable.

The inspection and comparison of *living* forms a to this argument examples without number. Of large terrestrial animals the structure is very mu alike; their senses nearly the same; their natu functions and passions nearly the same; their visce nearly the same, both in substance, shape, and offic digestion, nutrition, circulation, secretion, go on in similar manner, in all; the great circulating fluid the same; for, I think, no difference has been dis vered in the properties of *blood*, from whatever anim it be drawn. The experiment of transfusion prov that the blood of one animal will serve for anoth The *skeletons* also of the larger terrestrial anima show particular varieties, but still under a great ge al affinity. The resemblance is somewhat less, yet ufficiently evident, between quadrupeds and birds. They are all alike in five respects, for one in which ney differ.

In *fish*, which belong to another department, as it vere of nature, the points of comparison become ewer. But we never lose sight of our analogy, *e. g.* ve still meet with a stomach, a liver, a spine; with ile and blood; with teeth; with eyes, (which eyes re only slightly varied from our own, and which ariation, in truth, demonstrates, not an interruption, ut a continuance of the same exquisite plan; for it is ne adaptation of the organ to the element, viz. to the ifferent refraction of light passing into the eye out of denser medium.) The provinces, also, themselves of vater and earth, are connected by the species of animals which inhabit both; and also by a large tribe of quatic animals, which closely resemble the terrestrial n their internal structure; I mean the cetaceous tribe, which have hot blood, respiring lungs, bowels, and ther essential parts, like those of land-animals. This imilitude, surely, bespeaks the same creation and the ame Creator.

Insects and *shell-fish* appear to me to differ from ther classes of animals the most widely of any. Yet ven here, besides many points of particular resemlance, there exists a general relation of a peculiar ind. It is the relation of inversion; the law of conrariety: namely, that, whereas, in other animals, the ones, to which the muscles are attached, lie *within* ne body, in insects and shell-fish they lie on the *out*

side of it. The shell of a lobster performs to the ar
mal the office of a *bone*, by furnishing to the tendo
that fixed basis or immovable fulcrum, without whic
mechanically, they could not act. The crust of an i
sect is its shell, and answers the like purpose. T
shell also of an oyster stands in the place of a *bon*
the bases of the muscles being fixed to it, in the san
manner as, in other animals, they are fixed to t
bones. All which (under wonderful varieties, indee
and adaptations of form) confesses an imitation, a r
membrance, a carrying on of the same plan.

The observations here made are equally applicab
to plants; but, I think, unnecessary to be pursued.
is a very striking circumstance, and also sufficient
prove all which we contend for, that, in this part lik
wise of organized nature, we perceive a continuati
of the *sexual* system.

Certain however it is, that the whole argument f
the Divine unity goes no further than to an unity
counsel.

It may likewise be acknowledged, that no arg
ments which we are in possession of exclude the m
nistry of subordinate agents. If such there be, the
act under a presiding, a controlling will; because the
act according to certain general restrictions, by certa
common rules, and, as it should seem, upon a gener
plan: but still such agents, and different ranks, ar
classes and degrees of them, may be employed.

CHAPTER XXVI.

OF THE GOODNESS OF THE DEITY.

The proof of the *Divine goodness* rests upon two ropositions: each, as we contend, capable of being ıade out by observations drawn from the appearanes of nature.

The first is, "that in a vast plurality of instances in hich contrivance is perceived, the design of the conivance is *beneficial.*"

The second, "that the Deity has superadded *pleaıre* to animal sensations beyond what was necessary r any other purpose, or when the purpose, so far as was necessary, might have been effected by the opeıtion of pain."

First, "in a vast plurality of instances in which ontrivance is perceived, the design of the contrivance *beneficial.*"

No productions of nature display contrivance so ıanifestly as the parts of animals; and the parts of nimals have all of them, I believe, a real, and, with ery few exceptions, all of them a known and intelliible subserviency to the use of the animal. Now, hen the multitude of animals is considered, the numer of parts in each, their figure and fitness, the faculles depending upon them, the variety of species, the omplexity of structure, the success, in so many cases, nd felicity of the result, we can never reflect without the profoundest adoration, upon the character of th Being from whom all these things have proceeded we cannot help acknowledging what an exertion benevolence creation was; of a benevolence how m nute in its care, how vast in its comprehension!

When we appeal to the parts and faculties of an mals, and to the limbs and senses of animals in part cular, we state, I conceive, the proper medium of pro for the conclusion which we wish to establish. I wi not say that the insensible parts of nature are mad solely for the sensitive parts: but this I say, tha when we consider the benevolence of the Deity, w can only consider it in relation to sensitive bein Without this reference, or referred to any thing els the attribute has no object; the term has no meanin Dead matter is nothing. The parts, therefore, esp cially the limbs and senses, of animals, although the constitute, in mass, and quantity, a small portion the material creation, yet, since they alone are instr ments of perception, they compose what may be cal ed the whole of visible nature, estimated with a vie to the disposition of its Author. Consequently, it is *these* that we are to seek his character. It is by the that we are to prove that the world was made with benevolent design.

Nor is the design abortive. It is a happy world aft all. The air, the earth, the water teem with delight existence. In a spring noon, or a summer evening, whichever side I turn my eyes, myriads of happ beings crowd upon my view. "The insect youth a on the wing." Swarms of new-born *flies* are tryin heir pinions in the air. Their sportive motions, their vanton mazes, their gratuitous activity, their continual hange of place without use or purpose, testify their by, and the exultation which they feel in their lately iscovered faculties. A *bee* amongst the flowers in pring is one of the most cheerful objects that can be boked upon. Its life appears to be all enjoyment; so usy, and so pleased; yet it is only a specimen of in-ect life, with which, by reason of the animal being alf domesticated, we happen to be better acquainted ian we are with that of others. The *whole-winged* isect tribe, it is probable, are equally intent upon ieir proper employments, and, under every variety of onstitution, gratified, and perhaps equally gratified, y the offices which the Author of their nature has ssigned to them. But the atmosphere is not the only cene of enjoyment for the insect race. Plants are co-ered with aphides, greedily sucking their juices, and onstantly, as it should seem, in the act of sucking. It annot be doubted but that this is a state of gratifica-on. What else should fix them so close to the opera-on, and so long? Other species are *running about*, rith an alacrity in their motions which carries with it very mark of pleasure. Large patches of ground are ometimes half covered with these brisk and sprightly atures. If we look to what the *waters* produce, hoals of the fry of fish frequent the margins of ri-ers, of lakes, and of the sea itself. These are so happy iat they know not what to do with themselves. Their ttitudes, their vivacity, their leaps out of the water, ieir frolics in it, (which I have noticed a thousand times with equal attention and amusement,) all co duce to show their excess of spirits, and are simp the effects of that excess. Walking by the sea-side a calm evening, upon a sandy shore, and with ebbing tide, I have frequently remarked the appea ance of a dark cloud, or, rather, very thick mist, han ing over the edge of the water, to the height, perha of half a yard, and of the breadth of two or thr yards, stretching along the coast as far as the e could reach, and always retiring with the wat When this cloud came to be examined it proved to nothing else than so much space filled with you *shrimps* in the act of bounding into the air from t shallow margin of the water, or from the wet san If any motion of a mute animal could express deligl it was this: if they had meant to make signs of the happiness, they could not have done it more intellig bly. Suppose, then, what I have no doubt of, each i dividual of this number to be in a state of positive e joyment; what a sum, collectively, of gratification a pleasure have we here before our view!

The *young* of all animals appear to me to recei pleasure simply from the exercise of their limbs a bodily faculties, without reference to any end to attained, or any use to be answered by the exertio A child, without knowing any thing of the use language, is in a high degree delighted with bei able to speak. Its incessant repetition of a few artic late sounds, or, perhaps, of the single word which has learnt to pronounce, proves this point clearly. N is it less pleased with its first successful endeavors valk, or rather to run, (which precedes walking,) although entirely ignorant of the importance of the attainment to its future life, and even without applying t to any present purpose. A child is delighted with peaking, without having any thing to say, and with valking, without knowing where to go. And, prior to oth these, I am disposed to believe, that the waking ours of infancy are agreeably taken up with the exrcise of vision, or perhaps, more properly speaking, vith learning to see.

But it is not for youth alone that the great Parent of reation hath provided. Happiness is found with the urring cat, no less than with the playful kitten; in ie arm-chair of dozing age, as well as in either the prightliness of the dance, or the animation of the hase. To novelty, to acuteness of sensation, to hope, o ardor of pursuit, succeeds, what is, in no inconsideable degree, an equivalent for them all, "perception f ease." Herein is the exact difference between the oung and the old. The young are not happy but vhen enjoying pleasure; the old are happy when free om pain. And this constitution suits with the derees of animal power which they respectively posess. The vigor of youth was to be stimulated to ction by impatience of rest; whilst to the imbecility f age quietness and repose become positive gratificaons. In one important respect the advantage is with ie old. A state of ease is, generally speaking, more ttainable than a state of pleasure. A constitution, ierefore, which can enjoy ease, is preferable to that vhich can taste only pleasure. This same perception of ease oftentimes renders old age a condition of grea comfort; especially when riding at its anchor after busy or tempestuous life. It is well described by Rous seau, to be the interval of repose and enjoyment be tween the hurry and the end of life. How far th same cause extends to other animal natures cannot b judged of with certainty. The appearance of satisfac tion with which most animals, as their activity sul sides, seek and enjoy rest, affords reason to believe tha this source of gratification is appointed to advance life, under all, or most, of its various forms. In th species with which we are best acquainted, namel our own, I am far, even as an observer of human lif from thinking that youth is its happiest season, muc less the only happy one: as a christian, I am willin to believe that there is a great deal of truth in the fo lowing representation given by a very pious writer a well as excellent man:* "To the intelligent and vi tuous, old age presents a scene of tranquil enjoyment of obedient appetite, of well-regulated affections, c maturity in knowledge, and of calm preparation fo immortality. In this serene and dignified state, place as it were on the confines of two worlds, the mind c a good man reviews what is past with the complacen cy of an approving conscience; and looks forwar with humble confidence in the mercy of God, an with devout aspirations towards his eternal and eve increasing favor."

* Father's Instructions; by Dr. Percival, of Manchester, p. 317.

What is seen in different stages of the same life, is till more exemplified in the lives of different animals. nimal enjoyments are infinitely *diversified.* The nodes of life, to which the organization of different nimals respectively determines them, are not only of arious but of opposite kinds. Yet each is happy in its wn. For instance: animals of prey live much alone; nimals of a milder constitution in society. Yet the erring, which lives in shoals, and the sheep, which ives in flocks, are not more happy in a crowd, or nore contented amongst their companions, than is the ike, or the lion, with the deep solitudes of the pool, r the forest.

But it will be said, that the instances which we ave here brought forward, whether of vivacity or re-ose, or of apparent enjoyment derived from either, are icked and favorable instances. We answer, first, that hey are instances, nevertheless, which comprise large rovinces of sensitive existence; that every case which ve have described is the case of millions. At this mo-nent, in every given moment of time, how many my-iads of animals are eating their food, gratifying their ppetites, ruminating in their holes, accomplishing heir wishes, pursuing their pleasures, taking their astimes! In each individual, how many things must o right for it to be at ease; yet how large a propor-ion out of every species is so in every assignable in-stant! Secondly, we contend, in the terms of our ori-inal proposition, that throughout the whole of life, as t is diffused in nature, and as far as we are acquaint-d with it, looking to the average of sensations, the

plurality and the preponderancy is in favor of happ
ness by a vast excess. In our own species, in whic
perhaps the assertion may be more questionable tha
any other, the prepollency of good over evil, of healt
for example, and ease, over pain and distress, is evin
ed by the very notice which calamities excite. Wh
inquiries does the sickness of our friends produc
what conversation their misfortunes! This shows th
the common course of things is in favor of happines
that happiness is the rule, misery the exception. We
the order reversed, our attention would be called
examples of health and competency, instead of disea
and want.

One great cause of our insensibility to the goodne
of the Creator, is the very *extensiveness* of his bount
We prize but little what we share only in commo
with the rest, or with the generality of our specie
When we hear of blessings we think forthwith of su
cesses, of prosperous fortunes, of honors, riches, pr
ferments, *i. e.* of those advantages and superioriti
over others which we happen either to possess, or
be in pursuit of, or to covet. The common benefits
our nature entirely escape us. Yet these are the gre
things. These constitute what most properly ought
be accounted blessings of Providence: what alone,
we might so speak, are worthy of its care. Night
rest and daily bread, the ordinary use of our limb
and senses, and understandings, are gifts which adm
of no comparison with any other. Yet because almo
every man we meet with possesses these, we leav
them out of our enumeration. They raise no sent

ıent; they move no gratitude. Now, herein is our ıdgment perverted by our selfishness. A blessing ıght in truth to be the *more* satisfactory, the bounty t least of the donor is rendered more conspicuous, by s very diffusion, its commonness, its cheapness: by s falling to the lot, and forming the happiness of the reat bulk and body of our species, as well as of our-elves. Nay, even when we do not possess it, it ought be matter of thankfulness that others do. But we ave a different way of thinking. We court distinc-on. That is not the worst: we *see* nothing but what as distinction to recommend it. This necessarily con-racts our views of the Creator's beneficence within a arrow compass; and most unjustly. It is in those ıings which are so common as to be no distinction, ıat the amplitude of the Divine benignity is perceived.

But pain, no doubt, and privations exist, in nume-ous instances, and to a great degree, which collec-vely would be very great, if they were compared vith any other thing than with the mass of animal ruition. For the application, therefore, of our propo-ition to that *mixed* state of things which these excep-ions induce, two rules are necessary, and both, I think, ıst and fair rules. One is, that we regard those effects lone which are accompanied with proofs of intention: The other, that when we cannot resolve all appear-nces into benevolence of design, we make the few ive place to the many; the little to the great; that we ake our judgment from a large and decided prepon-lerancy, if there be one.

I crave leave to transcribe into this place what I have said upon this subject in my Moral Philosophy

"When God created the human species, either h wished their happiness, or he wished their misery, o he was indifferent and unconcerned about either.

"If he had wished our misery, he might have mad sure of his purpose, by forming our senses to be s many sores and pains to us, as they are now instru ments of gratification and enjoyment; or by placin us amidst objects so ill suited to our perceptions as t have continually offended us, instead of ministerin to our refreshment and delight. He might have mad for example, every thing we tasted, bitter; every thin we saw, loathsome; every thing we touched, a sting every smell a stench; and every sound, a discord.

"If he had been indifferent about our happiness misery, we must impute to our good fortune, (as a design by this supposition is excluded,) both the ca pacity of our senses to receive pleasure, and the su ply of external objects fitted to produce it.

"But either of these, and still more, both of then being too much to be attributed to accident, nothin remains but the first supposition, that God, when h created the human species, wished their happines and made for them the provision which he has mad with that view and for that purpose.

"The same argument may be proposed in differe terms; *thus:* Contrivance proves design; and the pr dominant tendency of the contrivance indicates th disposition of the designer. The world abounds wi contrivances; and all the contrivances which we a acquainted with are directed to beneficial purpose

ïvil, no doubt, exists; but is never, that we can per-
eive, the *object* of contrivance. Teeth are contrived
eat, not to ache; their aching now and then is inci-
ental to the contrivance, perhaps inseparable from it:
even, if you will, let it be called a defect in the con-
ivance; but it is not the object of it. This is a dis-
nction which well deserves to be attended to. In de-
ribing implements of husbandry, you would hardly
y of the siekle, that it is made to cut the reaper's
and: though from the construction of the instrument,
d the manner of using it, this mischief often fol-
ws. But if you had occasion to describe instruments
torture, or execution,—this engine, you would say,
to extend the sinews: this to dislocate the joints;
is to break the bones; this to scorch the soles of the
et. Here, pain and misery are the very objects of the
ntrivance. Now, nothing of this sort is to be found
the works of nature. We never discover a train of
ntrivance to bring about an evil purpose. No anato-
ist ever discovered a system of organization calcu-
ted to produce pain and disease; or, in explaining
e parts of the human body, ever said, this is to irri-
te; this to inflame; this duct is to convey the gravel
the kidneys; this gland to secrete the humor which
rms the gout: if by chance he come at a part of
hich he knows not the use, the most he can say is,
at it is useless; no one ever suspects that it is put
ere to incommode, to annoy, or to torment."

The TWO CASES which appear to me to have the
ost difficulty in them, as forming the most of the ap-
earance of exception to the representation here given,

are those of *venomous* animals, and of animals *preying* upon one another. These properties of animals, wherever they are found, must, I think, be referred to design; because there is in all cases of the first, and in most cases of the second, an express and distinct organization provided for the producing of them. Under the first head, the fangs of vipers, the stings of wasps and scorpions, are as clearly intended for their purpose, as any animal structure is for any purpose the most incontestably beneficial. And the same thing must, under the second head, be acknowledged of the talons and beaks of birds, of the tusks, teeth and claws of beasts of prey; of the shark's mouth, of the spider's web, and of numberless weapons of offence belonging to different tribes of voracious insects. We cannot, therefore, avoid the difficulty by saying that the effect was not intended. The only question open to us is, whether it be ultimately evil. From the confessed and felt imperfection of our knowledge, we ought to presume that there may be consequences of this economy which are hidden from us: from the benevolence which pervades the general designs of nature, we ought also to presume, that these consequences, if they could enter into our calculation, would turn the balance on the favorable side. Both these I contend to be reasonable presumptions. Not reasonable presumptions if these two cases were the only cases which nature presented to our observation; but reasonable presumptions under the reflection, that the cases in question are combined with a multitude of intentions, all proceeding from the same author, and all, except these, ected to ends of undisputed utility. Of the vindica-ns, however, of this economy, which we are able to sign, such as most extenuate the difficulty are the lowing:

With respect to *venomous* bites and stings, it may observed,—

1. That, the animal itself being regarded, the facul-complained of is *good;* being conducive, in all cases, the defence of the animal; in some cases, to the oduing of its prey; and in some, probably, to the ling of it, when caught, by a mortal wound, inflict-in the passage to the stomach, which may be no s merciful to the victim than salutary to the de-urer. In the viper, for instance, the poisonous fang y do that which, in other animals of prey, is done the crush of the teeth. Frogs and mice might be allowed alive without it.

2. But it will be said, that this provision, when it nes to the case of bites, deadly even to human bo-s, and to those of large quadrupeds, is greatly *over-ne;* that it might have fulfilled its use, and yet have en much less deleterious than it is. Now I believe case of bites which produce death in large animals stings I think there are none) to be very few. The periments of the Abbé Fontana, which were nume-is, go strongly to the proof of this point. He found t it required the action of five exasperated vipers kill a dog of a moderate size; but that to the kill-of a mouse, or a frog, a single bite was sufficient; ich agrees with the use which we assign to the fa-ty. The Abbé seemed to be of opinion, that the bite

even of the rattlesnake would not usually be mort
allowing, however, that in certain particularly unf
tunate cases, as when the puncture had touched so
very tender part, pricked a principal nerve, for
stance, or, as it is said, some more considerable ly
phatic vessel, death might speedily ensue.

3. It has been, I think, very justly remarked, co
cerning serpents, that, whilst only a few species p
sess the venomous property, that property guards t
whole tribe. The most innocuous snake is avoid
with as much care as a viper. Now the terror w
which large animals regard this class of reptiles is
protection; and this terror is founded on the formic
ble revenge which a few of the number, compared w
the whole, are capable of taking. The species of s
pents, described by Linnæus, amount to two hundr
and eighteen, of which thirty-two only are poisono

4. It seems to me, that animal constitutions are p
vided, not only for each element, but for each state
the elements, *i. e.* for every climate, and for every te
perature: and that part of the mischief complained
arises from animals (the human animal most especi
ly) occupying situations upon the earth which do n
belong to them, nor were ever intended for their h
bitation. The folly and wickedness of mankind, a
necessities proceeding from these causes, have driv
multitudes of the species to seek a refuge among
burning sands, whilst countries blessed with hospi
ble skies, and with the most fertile soils, remain
most without a human tenant. We invade the terri
ries of wild beasts and venomous reptiles, and th

mplain that we are infested by their bites and stings. me accounts of Africa place this observation in a rong point of view. "The deserts," says Adamson, are entirely barren, except where they are found to oduce serpents; and in such quantities, that some tensive plains are almost entirely covered with em." These are the natures appropriated to the situion. Let them enjoy their existence; let them have eir country. Surface enough will be left to man, ough his numbers were increased a hundred-fold, d left to him, where he might live exempt from ese annoyances.

The SECOND CASE, viz. that of animals *devouring* e another, furnishes a consideration of much larger tent. To judge whether, as a general provision, this n be deemed an *evil*, even so far as we understand consequences, which, probably, is a partial underanding, the following reflections are fit to be atnded to.

1. Immortality upon this earth is out of the question. ithout death there could be no generation, no sexes, parental relation, *i. e.* as things are constituted, no imal happiness. The particular duration of life, asgned to different animals, can form no part of the jection; because, whatever that duration be, whilst remains finite and limited, it may always be asked, hy it is no longer. The natural age of different anials varies from a single day to a century of years. o account can be given of this; nor could any be ven, whatever other proportion of life had obtained nongst them.

The term then of life in different animals being th same as it is, the question is, what mode of taking i away is the best even for the animal itself.

Now, according to the established order of natur (which we must suppose to prevail, or we cannot rea son at all upon the subject,) the three methods b which life is usually put an end to are acute disease decay, and violence. The simple and natural life o *brutes* is not often visited by acute distempers; no could it be deemed an improvement of their lot if the were. Let it be considered, therefore, in what a con dition of suffering and misery a brute animal is place which is left to perish by *decay*. In human sicknes or infirmity, there is the assistance of man's rationa fellow-creatures, if not to alleviate his pains at least t minister to his necessities, and to supply the place o his own activity. A brute, in his wild and natura state, does every thing for himself. When his strengt therefore, or his speed, or his limbs, or his senses fa him, he is delivered over, either to absolute famine c to the protracted wretchedness of a life slowly waste by the scarcity of food. Is it then to see the world fil ed with drooping, superannuated, half-starved, help less, and unhelped animals, that you would alter th present system of pursuit and prey?

2. Which system is also to them the spring of mo tion and activity on both sides. The pursuit of it prey forms the employment, and appears to constitut the pleasure, of a considerable part of the animal crea tion. The using of the means of defence, or flight, o precaution, forms also the business of another part

d even of this latter tribe, we have no reason to ppose that their happiness is much molested by their rs. Their danger exists continually; and in some ses they seem to be so far sensible of it as to prole, in the best manner they can, against it; but it is ly when the attack is actually made upon them it they appear to suffer from it. To contemplate insecurity of their condition with anxiety and ead, requires a degree of reflection, which (happily themselves) they do not possess. A *hare*, notwithnding the number of its dangers and its enemies, is playful an animal as any other.

3. But, to do justice to the question, the system of imal *destruction* ought always to be considered in ict connection with another property of animal nae, viz. *superfecundity*. They are countervailing alities. One subsists by the correction of the other. treating, therefore, of the subject under this view, hich is, I believe, the true one,) our business will first, to point out the advantages which are gained the powers in nature of a superabundant multiplizion; and then to show, that these advantages are many reasons for appointing that system of nationhostilities which we are endeavoring to account for. In almost all cases nature produces her supplies th profusion. A single cod-fish spawns, in one sea1, a greater number of eggs than all the inhabitants England amount to. A thousand other instances of olific generation might be stated, which, though not ual to this, would carry on the increase of the spes with a rapidity which outruns calculation, and to

an immeasurable extent. The advantages of such a constitution are two; first, that it tends to keep th world always full; whilst, secondly, it allows the pro portion between the several species of animals to b differently modified, as different purposes require, o as different situations may afford for them room an food. Where this vast fecundity meets with a vacan cy fitted to receive the species, there it operates wit its whole effect; there it pours in its numbers and re plenishes the waste. We complain of what we cal the exorbitant multiplication of some troublesome in sects; not reflecting that large portions of nature migh be left void without it. If the accounts of traveller may be depended upon, immense tracts of forests i North America would be nearly lost to sensitive exist ence if it were not for *gnats*. "In the thinly inhabit ed regions of America, in which the waters stagnat and the climate is warm, the whole air is filled wit crowds of these insects." Thus it is, that where w looked for solitude and death-like silence, we mee with animation, activity, enjoyment; with a busy, happy, and a peopled world. Again; hosts of *mic* are reckoned amongst the plagues of the north-eas part of Europe; whereas vast plains in Siberia, as w learn from good authority, would be lifeless withou them. The Caspian deserts are converted by thei presence into crowds of warrens. Between the Volg and the Yaik, and in the country of Hyrcania, th ground, says Pallas, is in many places *covered* wit little hills, raised by the earth cast out in forming th burrows. Do we so envy these blissful abodes as t onounce the fecundity by which they are supplied ith inhabitants to be an evil; a subject of complaint id not of praise? Further; by virtue of this same perfecundity, what we term destruction becomes al- ost instantly the parent of life. What we call blights e oftentimes legions of animated beings, claiming eir portion in the bounty of nature. What corrupts e produce of the earth to us prepares it for them. id it is by means of their rapid multiplication that ey take possession of their pasture; a slow propaga- n would not meet the opportunity.

But in conjunction with the occasional use of this uitfulness, we observe, also, that it allows the propor- n between the several species of animals to be dif- rently modified, as different purposes of utility may quire. When the forests of America come to be eared, and the swamps drained, our gnats will give ace to other inhabitants. If the population of Europe ould spread to the north and the east, the mice will tire before the husbandman and the shepherd, and eld their station to herds and flocks. In what con- rns the human species, it may be a part of the heme of Providence, that the earth should be inha- ted by a shifting, or perhaps a circulating population. this economy, it is possible that there may be the llowing advantages: When old countries are become ceedingly corrupt, simpler modes of life, purer mo- ls, and better institutions, may rise up in new ones, hilst fresh soils reward the cultivator with more entiful returns. Thus the different portions of the obe come into use in succession, as the residence of man; and, in his absence, entertain other guests which, by their sudden multiplication, fill the chasm In domesticated animals, we find the effect of thei fecundity to be that we can always command *num bers;* we can always have as many of any particula species as we please, or as we can support. Nor do w complain of its excess; it being much more easy t regulate abundance than to supply scarcity.

But then this *superfecundity*, though of great occa sional use and importance, exceeds the ordinary capa city of nature to receive or support its progeny. Al superabundance supposes destruction, or must destro itself. Perhaps there is no species of terrestrial ani mals whatever, which would not overrun the earth, i it were permitted to multiply in perfect safety; or o fish, which would not fill the ocean: at least, if an single species were left to their natural increase with out disturbance or restraint, the food of other specie would be exhausted by their maintenance. It is ne cessary, therefore, that the effects of such prolific fa culties be curtailed. In conjunction with other check and limits, all subservient to the same purpose, are th *thinnings* which take place among animals by thei action upon one another. In some instances we our selves experience, very directly, the use of these hos tilities. One species of insects rids us of another spe cies; or reduces their ranks. A third species, perhaps keeps the second within bounds; and birds or lizard are a fence against the ordinate increase by whic even these last might infest us. In other, more nume rous, and possibly more important instances, this dis osition of things, although less necessary or useful to is, and of course less observed by us, may be necesary and useful to certain other species; or even for he preventing of the loss of certain species from the niverse: a misfortune which seems to be studiously uarded against. Though there may be the appearnce of failure in some of the details of Nature's vorks, in her great purposes there never are. Her pecies never fail. The provision which was originally nade for continuing the replenishment of the world as proved itself to be effectual through a long sucession of ages.

What further shows, that the system of destruction mongst animals holds an express relation to the sysem of fecundity,—that they are parts indeed of one ompensatory scheme,—is, that in each species the feundity bears a proportion to the smallness of the animal, to the weakness, to the shortness of its natural erm of life, and to the dangers and enemies by which t is surrounded. An elephant produces but one calf; butterfly lays six hundred eggs. Birds of prey selom produce more than two eggs; the sparrow tribe, nd the duck tribe, frequently sit upon a dozen. In he rivers, we meet with a thousand minnows for one ike; in the sea, a million of herrings for a single hark. Compensation obtains throughout. Defenceessness and devastation are repaired by fecundity.

We have dwelt the longer on these considerations, ecause the subject to which they apply, namely, that f animals *devouring* one another, forms the chief, if ot the only instance, in the works of the Deity, of an

economy, stamped by marks of design, in which th
character of utility can be called in question. Th
case of *venomous* animals is of much inferior conse-
quence to the case of prey, and, in some degree, i
also included under it. To both cases it is probabl
that many more reasons belong than those of whicl
we are in possession.

Our FIRST PROPOSITION, and that which we hav
hitherto been defending, was, "that, in a vast plura-
lity of instances, in which *contrivance* is perceived
the design of the contrivance is beneficial."

Our SECOND PROPOSITION is, "that the Deity ha
added *pleasure* to animal sensations, beyond wha
was necessary for any other purpose, or when th
purpose, so far as it was necessary, might have bee
effected by the operation of pain."

This proposition may be thus explained: The ca-
pacities, which, according to the established course o
nature, are *necessary* to the support or preservation o
an animal, however manifestly they may be the resul
of an organization contrived for the purpose, can onl
be deemed an act or a part of the same will, as tha
which decreed the existence of the animal itself; be-
cause, whether the creation proceeded from a benevo-
lent or a malevolent being, these capacities must hav
been given, if the animal existed at all. Animal pro-
perties, therefore, which fall under this description, d
not strictly prove the goodness of God; they ma
prove the existence of the Deity; they may prove a
high degree of power and intelligence: but they d
not prove his goodness; forasmuch as they must have

een found in any creation which was capable of connuance, although it is possible to suppose that such a reation might have been produced by a being whose iews rested upon misery.

But there is a class of properties, which may be said) be superadded from an intention expressly directed) happiness; an intention to give a happy existence istinct from the general intention of providing the ieans of existence; and that is, of capacities for pleaure, in cases wherein, so far as the conservation of the idividual or of the species is concerned, they were not vanted, or wherein the purpose might have been seured by the operation of pain. The provision which s made of a variety of objects, not necessary to life, nd ministering only to our pleasures; and the proerties given to the necessaries of life themselves, by vhich they contribute to pleasure as well as preservaion; show a further design than that of giving exstence.*

A single instance will make all this clear. Assumig the necessity of food for the support of animal fe, it is requisite that the animal be provided with rgans fitted for the procuring, receiving, and digesting f its food. It may also be necessary, that the animal e impelled by its sensations to exert its organs. But ie pain of hunger would do all this. Why add pleaure to the act of eating; sweetness and relish to food?

* See this topic considered in Dr. Balguy's Treatise upon the Divine enevolence. This excellent author first, I think, proposed it; and nearly the terms in which it is here stated. Some other observations also un er this head are taken from that treatise.

why a new and appropriate sense for the perception o the pleasure? Why should the juice of a peach appli ed to the palate, affect the part so differently fron what it does when rubbed upon the palm of th hand? This is a constitution which, so far as appear to me, can be resolved into nothing but the pure be nevolence of the Creator. Eating is necessary; bu the pleasure attending it is not necessary: and tha this pleasure depends, not only upon our being in pos session of the sense of taste, which is different fron every other, but upon a particular state of the organ i which it resides, a felicitous adaptation of the organ t the object, will be confessed by any one, who may happen to have experienced that vitiation of tast which frequently occurs in fevers, when every taste i irregular, and every one bad.

In mentioning the gratifications of the palate, it may be said that we have made choice of a trifling exam ple. I am not of that opinion. They afford a shar of enjoyment to man; but to brutes I believe tha they are of very great importance. A horse at libert passes a great part of his waking hours in eating. T the ox, the sheep, the deer, and other ruminating ani mals, the pleasure is doubled. Their whole time al most is divided between browsing upon their pastur and chewing their cud. Whatever the pleasure be, i is spread over a large portion of their existence. I there be animals, such as the lupous fish, which swal low their prey whole, and at once, without any time as it should seem, for either drawing out, or relishing the taste in the mouth, is it an improbable conjecture, hat the seat of taste with them is in the stomach; or, t least, that a sense of pleasure, whether it be taste or ıot, accompanies the dissolution of the food in that re- eptacle, which dissolution in general is carried on ery slowly? If this opinion be right, they are more han repaid for the defect of palate. The feast lasts as ɔng as the digestion.

In seeking for argument, we need not stay to in- ist upon the comparative importance of our example: or the observation holds equally of all, or of three at east, of the other senses. The necessary purposes of ıearing might have been answered without harmony; f smell, without fragrance; of vision, without beauty. Now, "if the Deity had been indifferent about our hap- iness or misery, we must impute to our good fortune as all design by this supposition is excluded) both the apacity of our senses to receive pleasure, and the upply of external objects fitted to excite it." I allege hese as *two* felicities, for they are different things, yet oth necessary: the sense being formed, the objects, vhich were applied to it might not have suited it; he objects being fixed, the sense might not have agreed vith them. A coincidence is here required which no ccident can account for. There are three possible sup- ositions upon the subject, and no more. The first; hat the sense, by its original constitution, was made o suit the object: The second; that the object, by its riginal constitution, was made to suit the sense: The hird, that the sense is so constituted as to be able, ei- her universally, or within certain limits, by habit and amiliarity, to render every object pleasant. Whichever of these suppositions we adopt, the effect evinces, on the part of the Author of nature, a studious benevolence. If the pleasures which we derive from any of our senses depend upon an original congruity between the sense and the properties perceived by it, we know by experience that the adjustment demanded, with respect to the qualities which we conferred upon the objects that surround us, not only choice and selection out of a boundless variety of possible qualities with which these objects might have been endued, but a *proportioning also of degree*, because an excess or defect of intensity spoils the perception, as much almost as an error in the kind and nature of the quality. Likewise the degree of dulness or acuteness in the sense itself is no arbitrary thing, but, in order to preserve the congruity here spoken of, requires to be in an exact or near correspondency with the strength of the impression. The dulness of the senses forms the complaint of old age. Persons in fevers, and, I believe, in most maniacal cases, experience great torment from their preternatural acuteness. An increased, no less than an impaired sensibility, induces a state of disease and suffering.

The doctrine of a specific congruity between animal senses and their objects is strongly favored by what is observed of insects in the election of their food. Some of these will feed upon one kind of plant or animal, and upon no other; some caterpillars upon the cabbage alone; some upon the black currant alone. The species of caterpillar which eats the vine will starve upon the alder; nor will that which we find upon nnel touch the rose-bush. Some insects confine hemselves to two or three kinds of plants or aniials. Some again show so strong a preference as to fford reason to believe that, though they may be driven y hunger to others, they are led by the pleasure of iste to a few particular plants alone; and all this, s it should seem, independently of habit or imitation.

But should we accept the third hypothesis, and even arry it so far as to ascribe every thing which conerns the question to habit, (as in certain species, the uman species most particularly, there is reason to atibute something,) we have then before us an animal ipacity, not less perhaps to be admired than the nave congruities which the other scheme adopts. It innot be shown to result from any fixed necessity in ature, that what is frequently applied to the senses iould of course become agreeable to them. It is, so r as it subsists, a power of accommodation provided these senses by the Author of their structure, and rms a part of their perfection.

In whichever way we regard the senses, they appear be specific gifts, ministering, not only to preservaon, but to pleasure. But what we usually call the *nses*, are probably themselves far from being the ily vehicles of enjoyment, or the whole of our conitution which is calculated for the same purpose. Ve have many internal sensations of the most agreeble kind, hardly referable to any of the five senses. ome physiologists have holden that all secretion is easurable; and that the complacency which in health, ithout any external assignable object to excite it, we derive from life itself, is the effect of our secretion going on well within us. All this may be true; but i true, what reason can be assigned for it, except th will of the Creator? It may reasonably be asked, Wh is any thing a pleasure? and I know no answer whic can be returned to the question but that which refer it to appointment.

We can give no account whatever of our pleasure in the simple and original perception; and even whe physical sensations are assumed, we can seldom ac count for them in the secondary and complicate shapes in which they take the name of diversions. never yet met with a sportsman who could tell me i what the sport consisted; who could resolve it int its principle, and state that principle. I have been great follower of fishing myself, and in its cheerfu solitude have passed some of the happiest hours of sufficiently happy life: but, to this moment, I coul never trace out the source of the pleasure which i afforded me.

The "quantum in rebus inane!" whether applie to our amusements or to our graver pursuits, (to whic in truth, it sometimes equally belongs,) is always a unjust complaint. If trifles engage, and if trifles mak us happy, the true reflection suggested by the experi ment is upon the tendency of nature to gratificatio and enjoyment; which is, in other words, the good ness of its Author towards his sensitive creation.

Rational natures also, as such, exhibit qualitie which help to confirm the truth of our position. Th degree of understanding found in mankind is usuall

uch greater than what is necessary for mere preser-
ation. The pleasure of choosing for themselves, and
f prosecuting the object of their choice, should seem
be an original source of enjoyment. The pleasures
eceived from things, great, beautiful, or new, from
nitation, or from the liberal arts, are, in some mea-
ure, not only superadded, but unmixed, gratifications,
aving no pains to balance them.*

I do not know whether our attachment to *property*
e not something more than the mere dictate of rea-
on, or even than the mere effect of association. Pro-
erty communicates a charm to whatever is the object
f it. It is the first of our abstract ideas; it cleaves to
s the closest and the longest. It endears to the child
s plaything, to the peasant his cottage, to the land-
older his estate. It supplies the place of prospect and
cenery. Instead of coveting the beauty of distant situ-
tions, it teaches every man to find it in his own. It
ives boldness and grandeur to plains and fens, tinge
nd coloring to clays and fallows.

All these considerations come in aid of our *second*
roposition. The reader will now bear in mind what
ur two propositions were. They were, firstly, that in
vast plurality of instances, in which contrivance is
erceived, the design of the contrivance is beneficial:
econdly, that the Deity has added pleasure to animal
ensations beyond what was necessary for any other
urpose; or when the purpose, so far as it was neces-
ary, might have been effected by the operation of pain.

* Balguy on the Divine Benevolence.

Whilst these propositions can be maintained, we are authorized to ascribe to the Deity the character of benevolence; and what is benevolence at all, must in him be *infinite* benevolence, by reason of the infinite, that is to say, the incalculably great number of objects upon which it is exercised.

Of the ORIGIN OF EVIL no universal solution has been discovered; I mean, no solution which reaches to all cases of complaint. The most comprehensive is that which arises from the consideration of *general rules.* We may, I think, without much difficulty, be brought to admit the four following points: first, that important advantages may accrue to the universe from the order of nature proceeding according to general laws: secondly, that general laws, however well set and constituted, often thwart and cross one another: thirdly, that from these thwartings and crossings, frequent particular inconveniences will arise: and, fourthly, that it agrees with our observation to suppose, that some degree of these inconveniences takes place in the works of nature. These points may be allowed; and it may also be asserted, that the general laws with which we are acquainted are directed to beneficial ends. On the other hand, with many of these laws we are not acquainted at all, or we are totally unable to trace them in their branches and in their operation; the effect of which ignorance is, that they cannot be of importance to us as measures by which to regulate ur conduct. The conservation of them may be of im-ortance in other respects, or to other beings, but we re uninformed of their value or use; uninformed con-equently, when, and how far, they may or may not e suspended, or their effects turned aside, by a pre-iding and benevolent will, without incurring greater vils than those which would be avoided. The con-ideration, therefore, of general laws, although it may oncern the question of the origin of evil very nearly, which I think it does,) rests in views disproportionate o our faculties, and in a knowledge which we do not ossess. It serves rather to account for the obscurity f the subject, than to supply us with distinct answers o our difficulties. However, whilst we assent to the bove-stated propositions, as principles, whatever un-ertainty we may find in the application, we lay a round for believing that cases of apparent evil, for which *we* can suggest no particular reason, are go-erned by reasons which are more general, which lie eeper in the order of second causes, and which on hat account are removed to a greater distance from us.

The doctrine of *imperfections*, or, as it is called, of vils of imperfection, furnishes an account, founded, ke the former, in views of universal nature. The octrine is briefly this:—It is probable that creation may be better replenished by sensitive beings of dif-erent sorts, than by sensitive beings all of one sort. It s likewise probable, that it may be better replenished y different orders of beings rising one above another n gradation, than by beings possessed of equal de-grees of perfection. Now, a gradation of such beings implies a gradation of imperfections. No class can justly complain of the imperfections which belong to its place in the scale, unless it were allowable for it to complain that a scale of being was appointed in nature; for which appointment there appear to be reasons of wisdom and goodness.

In like manner *finiteness*, or what is resolvable into finiteness, in inanimate subjects, can never be a just subject of complaint; because if it were ever so, it would be always so; we mean, that we can never reasonably demand that things should be larger or more, when the same demand might be made, whatever the quantity or number was.

And to me it seems that the sense of mankind has so far acquiesced in these reasons, as that we seldom complain of evils of this class, when we clearly perceive them to be such. What I have to add, therefore, is, that we ought not to complain of some other evils, which stand upon the same foot of vindication as evils of confessed imperfection. We never complain that the globe of our earth is too small: nor should we complain if it were even much smaller. But where is the difference to us, between a less globe and part of the present being uninhabitable? The inhabitants of an island may be apt enough to murmur at the sterility of some parts of it, against its rocks, or sands, or swamps: but no one thinks himself authorized to murmur, simply because the island is not larger than it is. Yet these are the same griefs.

The above are the two metaphysical answers which have been given to this great question. They are not the worse for being metaphysical, provided they be founded (which I think they are) in right reasoning: but they are of a nature too wide to be brought under our survey, and it is often difficult to apply them in the detail. Our speculations, therefore, are perhaps better employed when they confine themselves within a narrower circle.

The observations which follow are of this more limited, but more determinate, kind.

Of *bodily pain*, the principal observation, no doubt, is that which we have already made, and already dwelt upon, viz. "that it is seldom the object of contrivance; that when it is so, the contrivance rests ultimately in good."

To which, however, may be added that the annexing of pain to the means of destruction is a salutary provision; inasmuch as it teaches vigilance and caution; both gives notice of danger, and excites those endeavors which may be necessary to preservation. The evil consequence, which sometimes arises from the want of that timely intimation of danger which pain gives, is known to the inhabitants of cold countries by the example of frost-bitten limbs. I have conversed with patients who had lost toes and fingers by this cause. They have in general told me, that they were totally unconscious of any local uneasiness at the time. Some I have heard declare, that, whilst they were about their employment, neither their situation, nor the state of the air, was unpleasant. They felt no pain; they suspected no mischief; till, by the application of warmth, they discovered, too late, the fatal injury which some of their extremities had suffered. I say that this shows the use of pain, and that we stand in need of such a monitor. I believe also that the use extends farther than we suppose, or can now trace; that to disagreeable sensations we, and all animals, owe, or have owed, many habits of action which are salutary, but which are become so familiar as not easily to be referred to their origin.

PAIN also itself is not without its *alleviations.* It may be violent and frequent; but it is seldom both violent and long-continued: and its pauses and intermissions become positive pleasures. It has the power of shedding a satisfaction over intervals of ease, which, I believe, few enjoyments exceed. A man resting from a fit of the stone or gout, is, for the time, in possession of feelings which undisturbed health cannot impart. They may be dearly bought, but still they are to be set against the price. And, indeed, it depends upon the duration and urgency of the pain, whether they be dearly bought or not. I am far from being sure that a man is not a gainer by suffering a moderate interruption of bodily ease for a couple of hours out of the four-and-twenty. Two very common observations favor this opinion: one is, that remissions of pain call forth, from those who experience them, stronger expressions of satisfaction and of gratitude towards both the author and the instruments of their relief, than are excited by advantages of any other kind: the second is, that the spirits of sick men do not sink in proportion to the acuteness of their sufferings; but rather appear to be roused and supported, not by ain, but by the high degree of comfort which they erive from its cessation, or even its subsidency, whenver that occurs; and which they taste with a relish hat diffuses some portion of mental complacency over he whole of that mixed state of sensations in which isease has placed them.

In connection with bodily pain may be considered odily *disease*, whether painful or not. Few diseases re fatal. I have before me the account of a dispenary in the neighborhood, which states six years' experience as follows:—

Admitted	6,420
Cured	5,476
Dead	234

ind this I suppose nearly to agree with what other imilar institutions exhibit. Now, in all these cases, ome disorder must have been felt, or the patients vould not have applied for a remedy; yet we see how arge a proportion of the maladies which were brought orward have either yielded to proper treatment, or, vhat is more probable, ceased of their own accord. Ve owe these frequent recoveries, and, where recovey does not take place, this patience of the human onstitution under many of the distempers by which t is visited, to two benefactions of our nature. One s, that she works within certain limits; allows of a ertain latitude within which health may be preserved, and within the confines of which it only suffers graduated diminution. Different quantities of food, lifferent degrees of exercise, different portions of sleep, different states of the atmosphere, are compatible with the possession of health. So likewise it is with the secretions and excretions, with many internal functions of the body, and with the state, probably, of most of its internal organs. They may vary considerably, not only without destroying life, but without occasioning any high degree of inconveniency. The other property of our nature, to which we are still more beholden, is its constant endeavor to restore itself, when disordered, to its regular course. The fluids of the body appear to possess a power of separating and expelling the noxious substance which may have mixed itself with them. This they do, in eruptive fevers, by a kind of despumation, as Sydenham calls it, analogous in some measure to the intestine action by which fermenting liquors work the yest to the surface. The solids, on their part, when their action is obstructed, not only resume that action as soon as the obstruction is removed, but they struggle with the impediment. They take an action as near to the true one as the difficulty and the disorganization with which they have to contend will allow of.

Of *mortal* diseases, the great use is to reconcile us to death. The horror of death proves the value of life. But it is in the power of disease to abate, or even extinguish, this horror; which it does in a wonderful manner, and, oftentimes, by a mild and imperceptible gradation. Every man who has been placed in a situation to observe it, is surprised with the change which has been wrought in himself, when he compares the view which he entertains of death upon a sick-bed, ith the heart-sinking dismay with which he should me time ago have met it in health. There is no si- ilitude between the sensations of a man led to exe- ıtion, and the calm expiring of a patient at the close ' his disease. Death to him is only the last of a long ain of changes; in his progress through which, it is ssible that he may experience no shocks or sudden ansitions.

Death itself, as a mode of removal and of succession, so connected with the whole order of our animal orld, that almost every thing in that world must be ıanged, to be able to do without it. It may seem like- ise impossible to separate the fear of death from the ıjoyment of life, or the perception of that fear from tional natures. Brutes are in a great measure deli- ered from all anxiety on this account by the inferio- y of their faculties; or rather they seem to be armed ith the apprehension of death just sufficiently to put em upon the means of preservation, and no farther. ıt would a human being wish to purchase this immu- ty at the expense of those mental powers which ena- e him to look forward to the future?

Death implies *separation:* and the loss of those hom we love must necessarily, so far as we can con- ive, be accompanied with pain. To the brute crea- on, nature seems to have stepped in with some secret ovision for their relief, under the rupture of their at- chments. In their instincts towards their offspring, d of their offspring to them, I have often been sur- ised to observe how ardently they love, and how on they forget. The pertinacity of human sorrow (upon which time also, at length, lays its softenin hand) is probably, therefore, in some manner connec ed with the qualities of our rational or moral natur One thing however is clear, viz. that it is better th we should possess affections, the sources of so man virtues and so many joys, although they be exposed the incidents of life as well as the interruptions mortality, than, by the want of them, be reduced to state of selfishness, apathy, and quietism.

Of other external evils, (still confining ourselves what are called physical or natural evils,) a consider ble part come within the scope of the following obse vation :—The great principle of human satisfaction *engagement.* It is a most just distinction, which th late Mr. Tucker has dwelt upon so largely in h works, between pleasures in which we are passive an pleasures in which we are active. And, I believe, ever attentive observer of human life will assent to his p sition, that, however grateful the sensations may occa sionally be in which we are passive, it is not thes but the latter class of our pleasures, which constitut satisfaction ; which supply that regular stream of mo derate and miscellaneous enjoyments in which hap piness, as distinguished from voluptuousness, consist Now for rational occupation, which is, in other word for the very material of contented existence, ther would be no place left, if either the things with whic we had to do were absolutely impracticable to our en deavors, or if they were too obedient to our uses. world, furnished with advantages on one side, an beset with difficulties, wants and inconveniences o e other, is the proper abode of free, rational, and tive natures, being the fittest to stimulate and exerse their faculties. The very *refractoriness* of the jects they have to deal with, contributes to this purse. A world in which nothing depended upon ourlves, however it might have suited an imaginary ce of beings, would not have suited mankind. Their ill, prudence, industry; their various arts and their st attainments, from the application of which they aw, if not their highest, their most permanent gratiations, would be insignificant, if things could be ther moulded by our volitions, or, of their own acrd, conformed themselves to our views and wishes. ow it is in this refractoriness that we discern the ed and principle of *physical* evil, as far as it arises om that which is external to us.

Civil evils, or the evils of civil life, are much more sily disposed of than physical evils: because they e, in truth, of much less magnitude, and also because ey result, by a kind of necessity, not only from the nstitution of our nature, but from a part of that conitution which no one would wish to see altered. The se is this: Mankind will in every country *breed up* a certain point of distress. That point may be different in different countries or ages, according to the tablished usages of life in each. It will also shift on the scale, so as to admit of a greater or less numr of inhabitants, according as the quantity of provion, which is either produced in the country, or supied to it from other countries, may happen to vary. ut there must always be such a point, and the species will always breed up to it. The order of genera-tion proceeds by something like a geometrical pro-gression. The increase of provision, under circum-stances even the most advantageous, can only assum the form of an arithmetic series. Whence it follow that the population will always overtake the provisio will pass beyond the line of plenty, and will continu to increase till checked by the difficulty of procurin subsistence.* Such difficulty, therefore, along with it attendant circumstances, *must* be found in every ol country; and these circumstances constitute what w call poverty, which necessarily imposes labor, servi-tude, restraint.

It seems impossible to people a country with inha-bitants who shall be all easy in circumstances. Fo suppose the thing to be done, there would be suc marrying and giving in marriage amongst them, a would in a few years change the face of affairs en-tirely: *i. e.* as would increase the consumption of thos articles which supplied the natural or habitual want of the country to such a degree of scarcity, as mus leave the greatest part of the inhabitants unable t procure them without toilsome endeavors; or, out o the different kinds of these articles to procure an kind except that which was most easily produced And this, in fact, describes the condition of the mas of the community in all countries: a condition una-voidably, as it should seem, resulting from the provi

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* See a statement of this subject in a late treatise upon population.

n which is made in the human, in common with animal constitutions, for the perpetuity and multication of the species.

It need not however dishearten any endeavors for public service, to know that population naturally ads upon the heels of improvement. If the condin of a people be meliorated, the consequence will either that the *mean* happiness will be increased, a greater number partake of it; or, which is most ely to happen, that both effects will take place toger. There may be limits fixed by nature to both, t they are limits not yet attained, nor even approach- in any country of the world.

And when we speak of limits at all, we have re-ect only to provisions for animal wants. There are rces, and means, and auxiliaries, and augmentans of human happiness, communicable without re-ction of numbers; as capable of being possessed a thousand persons as by one. Such are those ich flow from a mild, contrasted with a tyrannic vernment, whether civil or domestic; those which ing from religion; those which grow out of a sense of urity; those which depend upon habits of virtue, so-ety, moderation, order: those, lastly, which are found the possession of well-directed tastes and desires, npared with the dominion of tormenting, pernicious, ntradictory, unsatisfied, and unsatisfiable passions.

The *distinctions* of civil life are apt enough to be arded as evils by those who sit under them; but, my opinion, with very little reason.

In the first place, the advantages which the higher

conditions of life are supposed to confer, bear no pr
portion in value to the advantages which are bestow
ed by nature. The gifts of nature always surpass t
gifts of fortune. How much, for example, is activi
better than attendance; beauty than dress; appeti
digestion, and tranquil bowels, than all the studies
cookery, or than the most costly compilation of forc
or far-fetched dainties!

Nature has a strong tendency to equalization. Hab
the instrument of nature, is a great leveller; the
miliarity which it induces taking off the edge both
our pleasures and our sufferings. Indulgences whi
are habitual, keep us in ease, and cannot be carri
much further. So that with respect to the gratificatio
of which the senses are capable, the difference is
no means proportionable to the apparatus. Nay, so
as superfluity generates fastidiousness, the differen
is on the wrong side.

It is not necessary to contend, that the advantag
derived from wealth are none, (under due regulatio
they are certainly considerable,) but that they are n
greater than they ought to be. *Money* is the sweete
er of human toil; the substitute for coercion; the
conciler of labor with liberty. It is, moreover, the s
mulant of enterprise in all objects and undertaking
as well as of diligence in the most beneficial arts a
employments. Now, did affluence, when possesse
contribute nothing to happiness, or nothing beyo
the mere supply of necessaries,—and the secret shou
come to be discovered,—we might be in danger
losing great part of the uses which are at present d

ived to us through this important medium. Not only vould the tranquility of social life be put in peril by he want of a motive to attach men to their private oncerns; but the satisfaction which all men receive om success in their respective occupations, which ollectively constitutes the great mass of human comrt, would be done away in its very principle.

With respect to *station*, as it is distinguished from iches, whether it confer authority over others, or be ivested with honors which apply solely to sentiment nd imagination, the truth is that what is gained by ising through the ranks of life, is not more than sufcient to draw forth the exertions of those who are ngaged in the pursuits which lead to advancement, nd which, in general, are such as ought to be encouaged. Distinctions of this sort are subjects much iore of competition than of enjoyment; and in that ompetition their use consists. It is not, as hath been ightly observed, by what the *Lord Mayor* feels in his oach, but by what the *apprentice* feels who gazes at im, that the public is served.

As we approach the summits of human greatness, he comparison of good and evil, with respect to peronal comfort, becomes still more problematical; even llowing to ambition all its pleasures. The poet asks, "What is grandeur, what is power?" The philosoher answers, "Constraint and plague: *et in maximâ uâque fortunâ minimum licere.*" One very common rror misleads the opinion of mankind on this head, iz. that, universally, authority is pleasant, submission ainful. In the general course of human affairs, the very reverse of this is nearer the truth. Command i anxiety, obedience ease.

Artificial distinctions sometimes promote real equa lity. Whether they be hereditary, or be the homag paid to office, or the respect attached by public opinio to particular professions, they serve to *confront* tha grand and unavoidable distinction which arises fro property, and which is most overbearing where ther is no other. It is of the nature of property, not onl to be irregularly distributed, but to run into larg masses. Public laws should be so constructed as t favor its diffusion as much as they can. But all tha can be done by laws, consistently with that degree o government of his property which ought to be left t the subject, will not be sufficient to counteract thi tendency. There must always, therefore, be the di ference between rich and poor; and this differenc will be the more grinding when no pretension is a lowed to be set up against it.

So that the evils, if evils they must be called, whic spring either from the necessary subordinations o civil life, or from the distinctions which have natu rally, though not necessarily, grown up in most socie ties, so long as they are unaccompanied by privilege injurious or oppressive to the rest of the community are such as may, even by the most depressed ranks be endured with very little prejudice to their comfort

The mischiefs of which mankind are the occasio to one another, by their private wickednesses and cru elties; by tyrannical exercises of power; by rebel lions against just authority; by wars; bv nationa ealousies and competitions operating to the destruc- ion of third countries; or by other instances of mis onduct either in individuals or societies, are all to be esolved into the character of man as a *free agent* Free agency, in its very essence, contains liability to buse. Yet, if you deprive man of his free agency ou subvert his nature. You may have order from im and regularity, as you may from the tides or the rade-winds, but you put an end to his moral charac- er, to virtue, to merit, to accountableness, to the use ndeed of reason. To which must be added the ob- ervation, that even the bad qualities of mankind have n origin in their good ones. The case is this: Hu- nan passions are either necessary to human welfare, r capable of being made, and, in a great majority of nstances, in fact made, conducive to its happiness. These passions are strong and general; and, perhaps, vould not answer their purpose unless they were so. But strength and generality, when it is expedient that particular circumstances should be respected, become, f left to themselves, excess and misdirection. From which excess and misdirection, the vices of mankind the causes, no doubt, of much misery) appear to pring. This account, whilst it shows us the princi- le of vice, shows us, at the same time, the province of reason and of self-government; the want also of every support which can be procured to either from he aids of religion; and it shows this, without having ecourse to any native, gratuitous malignity in the uman constitution. Mr. Hume, in his posthumous lialogues, asserts, indeed, of *idleness*, or aversion to labor, (which he states to lie at the root of a conside-rable part of the evils which mankind suffer,) that it is simply and merely bad. But how does he distin-guish idleness from the love of ease? or is he sure that the love of ease in individuals is not the chief foundation of social tranquility? It will be found, I believe, to be true, that in every community there is a large class of its members, whose idleness is the best quality about them, being the corrective of other bad ones. If it were possible, in every instance, to give a right determination to industry, we could never have too much of it. But this is not possible, if men are to be free. And without this, nothing would be so dan-gerous as an incessant, universal, indefatigable activi-ty. In the civil world, as well as in the material, it is the *vis inertiæ* which keeps things in their places.

Natural Theology has ever been pressed with this question,—Why, under the regency of a supreme and benevolent Will, should there be in the world so much as there is of the appearance of *chance*?

The question in its whole compass lies beyond our reach: but there are not wanting, as in the origin of evil, answers which seem to have considerable weight in particular cases, and also to embrace a considerable number of cases.

I. There must be *chance* in the midst of design; by which we mean, that events which are not designed, necessarily arise from the pursuit of events which are designed. One man travelling to York, meets another man travelling to London. Their meeting is by chance, is accidental, and so would be called and reckoned, though the journeys which produced the meeting were, both of them, undertaken with design and from deliberation. The meeting, though accidental, was nevertheless hypothetically necessary, (which is the only sort of necessity that is intelligible,) for if the two journeys were commenced at the time, pursued in the direction, and with the speed, in which and with which, they were in fact begun and performed, the meeting could not be avoided. There was not, therefore, the less necessity in it for its being by chance. Again, the rencounter might be most unfortunate, though the errand upon which each party set out upon his journey were the most innocent or the most laudable. The by effect may be unfavorable, without impeachment of the proper purpose, for the sake of which the train, from the operation of which these consequences ensued, was put in motion. Although no cause act without a good purpose, accidental consequences, like these, may be either good or bad.

II. The *appearance of chance* will always bear a proportion to the ignorance of the observer. The cast of a die as regularly follows the laws of motion, as the going of a watch; yet, because we can trace the operation of those laws through the works and movements of the watch, and cannot trace them in the shaking or throwing of the die, (though the laws be the same, and prevail equally in both cases,) we call the turning up of the number of the die chance, the pointing of the index of the watch machinery, order, or by some name which excludes chance. It is the same in those events which depend upon the will of a free and rational agent. The verdict of a jury, the sentence of a judge, the resolution of an assembly, the issue of a contested election, will have more or less the appearance of chance, might be more or less the subject of a wager, according as we were less or more acquainted with the reasons which influenced the deliberation. The difference resides in the formation of the observer, and not in the thing itself; which, in all the cases proposed, proceeds from intelligence, from mind, from counsel, from design.

Now, when this one cause of the appearance of chance, viz. the ignorance of the observer, comes to be applied to the operations of the Deity, it is easy to foresee how fruitful it must prove of difficulties and of seeming confusion. It is only to think of the Deity, to perceive what variety of objects, what distance of time, what extent of space and action, his counsels may, or rather must, comprehend. Can it be wondered at, that, of the purposes which dwell in such a mind as this, so small a part should be known to us? It is only necessary, therefore, to bear in our thought, that in proportion to the inadequateness of our information, will be the quantity in the world of apparent chance.

III. In a great variety of cases, and of cases comprehending numerous subdivisions, it appears, for many reasons, to be better that events rise up by *chance*, or, more properly speaking, with the appearance of chance, than according to any observable rule whatever. This is not seldom the case, even in human arrangements. Each person's place and precedency, in a public meeting, may be determined by *lot*. Work and labor may be *allotted*. Tasks and burdens may be *allotted*:

—— —— Operumque laborem
Partibus æquabat justis, aut *sorte* trahebat.

Military service and station may be *allotted*. The distribution of provision may be made by *lot*, as it is in a sailor's mess; in some cases also, the distribution of favors may be made by *lot*. In all these cases, it seems to be acknowledged, that there are advantages in permitting events to chance superior to those which would or could arise from regulation. In all these cases also, though events rise up in the way of chance, it is by appointment that they do so.

In other events, and such as are independent of human will, the reasons for this preference of uncertainty to rule appear to be still stronger. For example: it seems to be expedient that the period of human life should be *uncertain*. Did mortality follow any fixed rule, it would produce a security in those that were at a distance from it, which would lead to the greatest disorders; and a horror in those who approached it, similar to that which a condemned prisoner feels on the night before his execution. But, that death be uncertain, the young must sometimes die as well as the old. Also were deaths never *sudden*, they who are in health would be too confident of life. The strong and the active who want most to be warned and checked, would live without apprehension or restraint. On the other hand, were sudden deaths very frequent, the sense of constant jeopardy would interfere too much with the degree of ease and enjoyment intended for us; and human life be too precarious for the business and interests which belong to it. There could not be dependence either upon our own lives, or the lives of those with whom we were connected, sufficient to carry on the regular offices of human society. The manner, therefore, in which death is made to occur, conduces to the purposes of admonition, without overthrowing the necessary stability of human affairs.

Disease being the forerunner of death, there is the same reason for its attacks coming upon us under the appearance of chance, as there is for uncertainty in the time of death itself.

The *seasons* are a mixture of regularity and chance. They are regular enough to authorize expectation, whilst their being, in a considerable degree, irregular, induces, on the part of the cultivators of the soil, a necessity for personal attendance, for activity, vigilance, precaution. It is this necessity which creates farmers; which divides the profit of the soil between the owner and the occupier; which by requiring expedients, by increasing employment, and by rewarding expenditure, promotes agricultural arts and agricultural life, of all modes of life the best, being the most conducive to health, to virtue, to enjoyment. I believe it to be found in fact, that where the soil is the most fruitful, and the seasons the most constant, there the condition of the cultivators of the earth is the most depressed.

Jncertainty, therefore, has its use even to those who sometimes complain of it the most. Seasons of scarcity hemselves are not without their advantages. They call forth new exertions; they set contrivance and ingenuity at work: they give birth to improvements in agriculture and economy; they promote the investigaion and management of public resources.

Again: there are strong intelligible reasons, why here should exist in human society great disparity of *wealth* and *station;* not only as these things are acquired in different degrees, but at the first setting out of life. In order, for instance, to answer the various demands of civil life, there ought to be amongst he members of every civil society a diversity of education, which can only belong to an original diversity of circumstances. As this sort of disparity, which ought o take place from the beginning of life, must *ex hypohesi*, be previous to the merit or demerit of the persons upon whom it falls, can it be better disposed of han by chance? *Parentage* is that sort of chance: yet it is the commanding circumstance which in general fixes each man's place in civil life, along with every thing which appertains to its distinctions. It may be the result of a beneficial rule, that the fortunes or honors of the father devolve upon the son; and, as t should seem, of a still more necessary rule, that the ow or laborious condition of the parent be communicated to his family; but with respect to the successor himself, it is the drawing of a ticket in a lottery. Inequalities, therefore, of fortune, at least the greatest part of them, viz. those which attend us from our birth, and depend upon our birth, may be left, as they are left to *chance*, without any just cause for questioning the regency of a supreme Disposer of events.

But not only the donation, when by the necessity of the case they must be gifts, but even the *acquirability* of civil advantages, ought perhaps, in a considerable degree, to lie at the mercy of chance. Some would have all the virtuous rich, or, at least, removed from the evils of poverty, without perceiving, I suppose, the consequence, that all the poor must be wicked. And how such a society could be kept in subjection to government, has not been shown: for the poor that is, they who seek their subsistence by constant manual labor, must still form the mass of the community; otherwise the necessary labor of life could not be carried on; the work could not be done, which the wants of mankind in a state of civilization, and still more, in a state of refinement, require to be done.

It appears to be also true, that the exigencies of social life call not only for an original diversity of *external* circumstances, but for a mixture of different faculties, tastes, and tempers. Activity and contemplation, restlessness and quiet, courage and timidity, ambition and contentedness, not to say even indolence and dulness, are all wanted in the world, all conduce to the well going on of human affairs, just as the rudder, the sails, and the ballast of a ship, all perform their part in the navigation. Now, since these characters require for their foundation different original talents, different dispositions, perhaps also different bodily constitutions; and since, likewise, it is appaently expedient that they be promiscuously scattered amongst the different classes of society,—can the distribution of talents, dispositions, and the constitutions upon which they depend, be better made than by *chance?*

The *opposites* of apparent chance are constancy and sensible interposition; every degree of *secret* direction being consistent with it. Now of *constancy*, or of fixed and known rules, we have seen in some cases the inapplicability; and inconveniences which we do not see, might attend their application in other cases. Of *sensible* interposition, we may be permitted to remark, that a Providence, always and certainly distinguishable, would be neither more nor less than miracles rendered frequent and common. It is difficult to judge of the state into which this would throw us. It is enough to say, that it would cast us upon a quite different dispensation from that under which we live. It would be a total and radical change. And the change would deeply affect, or perhaps subvert, the whole conduct of human affairs. I can readily believe, that, other circumstances being adapted to it, such a state might be better than our present state. It may be the state of other beings; it may be ours hereafter. But the question with which we are now concerned is, how far it would be consistent with our condition, supposing it in other respects to remain as it is? And in this question there seem to be reasons of great moment on the negative side. For instance: so long as bodily labor continues, on so many accounts, to be necessary for the bulk of mankind, any dependency upon supernatural aid, by unfixing those motives which promote exertion, or by relaxing those habits which engender patient industry, might introduce negligence, inactivity, and disorder, into the most useful occupations of human life; and thereby deteriorate the condition of human life itself.

As moral agents we should experience a still greater alteration; of which more will be said under the next article.

Although, therefore, the Deity, who possesses the power of winding and turning, as he pleases, the course of causes which issue from himself, do in fact interpose to alter or intercept effects which, without such interposition, would have taken place; yet it is by no means incredible that his Providence, which always rests upon final good, may have made a *reserve* with respect to the manifestation of his interference, a part of the very plan which he has appointed for our terrestrial existence, and a part conformable with, or in some sort required by, other parts of the same plan. It is at any rate evident, that a large and ample province remains for the exercise of Providence without its being naturally perceptible by us; because obscurity, when applied to the interruption of laws, bears a necessary proportion to the imperfection of our knowledge when applied to laws themselves, or rather to the effects which these laws, under their various and incalculable combinations, would of their own accord produce. And if it be said, that the doctrine of Divine Providence, by reason of the ambiguity under which its exertions present themselves, can be attended with no *practical* influence upon our conduct; that, although we believe ever so firmly that there is a Providence, we must prepare, and provide, and act, as if there were none; I answer, that this is admitted; and that we further allege, that so to prepare, and so to provide, is consistent with the most perfect assurance of the reality of a Providence: and not only so, but that it is, probably, one advantage of the present state of our information, that our provisions and preparations are not disturbed by it. Or if it be still asked, Of what use at all, then, is the doctrine, if it neither alter our measures nor regulate our conduct? I answer again, that it is of the greatest use, but that it is a doctrine of sentiment and piety, not (immediately at least) of action or conduct; that it applies to the consolation of men's minds, to their devotions, to the excitement of gratitude, the support of patience, the keeping alive and the strengthening of every motive for endeavoring to please our Maker; and that these are great uses.

Of all views under which human life has ever been considered, the most reasonable, in my judgement, is that which regards it as a state of *probation.* If the course of the world was separated from the contrivances of nature, I do not know that it would be necessary to look for any other account of it than what, if it may be called an account, is contained in the answer, that events rise up by chance. But since the contrivances of nature decidedly evince *intention;* and since the course of the world and the contrivances of nature have the same author, we are, by the force of this connection, led to believe that the appearance under which events take place is reconcilable with the supposition of design on the part of the Deity. It is enough that they be reconcilable with this supposition: and it is undoubtedly true that they may be reconcilable, though we cannot reconcile them. The mind, however, which contemplates the works of nature, and in those works sees so much of means directed to ends, of beneficial effects brought about by wise expedients, of concerted trains of causes terminating in the happiest results; so much, in a word, of counsel, intention, and benevolence; a mind, I say, drawn into the habit of thought, which these observations excite, can hardly turn its view to the condition of our own species without endeavoring to suggest to itself some purpose, some design, for which the state in which we are placed is fitted, and which it is made to serve. Now we assert the most probable supposition to be, that it is a state of moral probation; and that many things in it suit with this hypothesis which suit no other. It is not a state of unmixed happiness, or of happiness simply; it is not a state of designed misery, or of misery simply; it is not a state of retribution; it is not a state of punishment. It suits with none of these suppositions. It accords much better with the idea of its being a condition calculated for the production, exercise, and improvement of moral qualities, with a view to a future state, in which these qualities, after being so produced, exercised, and improved, may, by a new and more favorable constitution of things, receive their reward, or become their own. If it be said, that this is to enter upon a religious rather than a philosophical consideration, I answer, that the name of Religion ought to form no objection if it shall turn out to be the case that the more religious our views are the more probability they contain. The degree of beneficence, of benevolent intention and of power, exercised in the construction of sensitive beings, goes strongly in favor, not only of a creative but of a continuing care, that is, of a ruling Providence. The degree of chance which appears to prevail in the world requires to be reconciled with this hypothesis. Now it is one thing to maintain the doctrine of Providence along with that of a future state, and another thing without it. In my opinion, the two doctrines must stand or fall together. For although more of this apparent chance may perhaps, upon other principles, be accounted for than is generally supposed, yet a future state alone rectifies all disorders; and if it can be shown that the appearance of disorder is consistent with the uses of life as a *preparatory* state, or that in some respects it promotes these uses, then, so far as this hypothesis may be accepted, the ground of the difficulty is done away.

In the wide scale of human condition there is not, perhaps, one of its manifold diversities which does not bear upon the design here suggested. Virtue is infinitely various. There is no situation in which a rational being is placed, from that of the best-instructed christian down to the condition of the rudest barbarian, which affords not room for moral agency; for the acquisition, exercise, and display of voluntary qualities, good and bad. Health and sickness, enjoyment and suffering, riches and poverty, knowledge and ignorance, power and subjection, liberty and bondage, civilization and barbarity, have all their offices and duties, all serve for the *formation* of character: for, when we speak of a state of trial, it must be remembered that characters are not only tried, or proved, or detected, but that they are generated also, and *formed* by circumstances. The best dispositions may subsist under the most depressed, the most afflicted fortunes. A West-Indian slave, who, amidst his wrongs, retains his benevolence, I, for my part, look upon as amongst the foremost of human candidates for the rewards of virtue. The kind master of such a slave: that is, he who, in the exercise of an inordinate authority, postpones, in any degree, his own interest to his slave's comfort, is likewise a meritorious character: but still he is inferior to his slave. All, however, which I contend for is, that these destinies, opposite as they may be in every other view, are both *trials*, and equally such. The observation may be applied to every other condition: to the whole range of the scale, not excepting even its lowest extremity. *Savages* appear to us all alike; but it is owing to the distance at which we view savage life, that we perceive in it no discrimination of character. I make no doubt but that moral qualities, both good and bad, are called into action as much, and that they subsist in as great variety in these inartificial societies as they are or do in polished life. Certain at least it is, that the good and ill treatment which each individual meets with, depends more ıpon the choice and voluntary conduct of those about ıim, than it does or ought to do under regular institu-ions and the coercion of public laws. So again, to urn our eyes to the other end of the scale: namely, hat part of it which is occupied by mankind enjoying he benefits of learning, together with the lights of re-elation; there also the advantage is all along *proba-ionary*. Christianity itself, I mean the revelation of hristianity, is not only a blessing but a trial. It is one f the diversified means by which the character is ex-rcised: and they who require of christianity that the evelation of it should be universal, may possibly be ound to require that one species of probation should e adopted, if not to the exclusion of others, at least the narrowing of that variety which the wisdom of ıe Deity hath appointed to this part of his moral conomy.*

Now if this supposition be well founded: that is, if be true that our ultimate, or our most permanent appiness will depend, not upon the temporary condi-on into which we are cast, but upon our behavior in , then it is a much more fit subject of *chance* than e usually allow or apprehend it to be, in what man-er the variety of external circumstances, which sub-

* The reader will observe that I speak of the revelation of christianity distinct from christianity itself. The *dispensation* may already be uni-rsal. That part of mankind which never heard of CHRIST's name, may evertheless be redeemed: that is, be placed in a better condition, with spect to their future state, by his intervention; may be the objects of his nignity and intercession, as well as of the propitiatory virtue of his ssion. But this is not "natural theology;" therefore I will not dwell nger upon it.

sist in the human world, is distributed amongst th individuals of the species. "This life being a state o probation, it is immaterial," says Rousseau, "wha kind of trials we experience in it, provided they pro duce their effects." Of two agents who stand indiffer ent to the moral Governor of the universe, one ma be exercised by riches, the other by poverty. Th treatment of these two shall appear to be very oppo site, whilst in truth it is the same; for though, in ma ny respects, there be great disparity between the con ditions assigned, in one main article there may b none, viz. in that they are alike trials; have both thei duties and temptations, not less arduous or less dan gerous in one case than the other; so that if the fina award follow the character, the original distributio of the circumstances under which that character i formed, may be defended upon principles not only o justice but of equality. What hinders, therefore, bu that mankind may draw lots for their condition? They take their portion of faculties and opportunities, as any unknown cause, or concourse of causes, or as causes acting for other purposes, may happen to set them out but the event is governed by that which depends upon themselves, the application of what they have received. In dividing the talents, no rule was observed: none was necessary: in rewarding the use of them, that of the most correct justice. The chief difference at last appears to be, that the right use of more talents, *i. e.* of a greater trust, will be more highly rewarded than the right use of fewer talents, *i. e.* of a less trust. And since, for other purposes, it is expedient that there be ı inequality of concredited talents here, as well proıbly as an inequality of conditions hereafter, though l remuneratory,—can any rule, adapted to that ineıality, be more agreeable, even to our apprehensions ' distributive justice, than this is?

We have said that the appearance of *casualty* which tends the occurrences and events of life, not only ɔes not interfere with its uses as a state of probation, ıt that it promotes these uses.

Passive virtues, of all others the severest and the ost sublime; of all others, perhaps, the most acceptɔle to the Deity,—would, it is evident, be excluded ɔm a constitution in which happiness and misery reılarly followed virtue and vice. Patience and comɔsure under distress, affliction and pain; a steadfast ɛeping up of our confidence in God, and of our relince upon his final goodness, at the time when every ing present is adverse and discouraging; and (what no less difficult to retain) a cordial desire for the hapness of others, even when we are deprived of our vn; these dispositions, which constitute, perhaps, the ɜrfection of our moral nature, would not have found eir proper office and object in a state of avowed reibution; and in which, consequently, endurance of ʼil would be only submission to punishment.

Again: one man's sufferings may be another man's ial. The family of a sick parent is a school of filial ety. The charities of domestic life, and not only ese, but all the social virtues, are called out by disɛss. But then misery, to be the proper object of migation, or of that benevolence which endeavors to

relieve, must be really or apparently casual. It is upo
such sufferings alone that benevolence can operat
For were there no evils in the world but what we
punishments, properly and intelligibly such, benev
lence would only stand in the way of justice. Suc
evils, consistently with the administration of moral g
vernment, could not be prevented or alleviated, that
to say, could not be remitted in whole or in part, e
cept by the authority which inflicted them, or by a
appellate or superior authority. This consideratio
which is founded in our most acknowledged appr
hensions of the nature of penal justice, may posse
its weight in the Divine counsels. Virtue perhaps
the greatest of all ends. In human beings, relative vi
tues form a large part of the whole. Now relative vi
tue presupposes, not only the existence of evil, withou
which it could have no object, no material to wor
upon, but that evils be apparently, at least, *misfo
tunes*; that is, the effects of apparent chance. It ma
be in pursuance, therefore, and in furtherance of th
same scheme of probation, that the evils of life a
made so to present themselves.

I have already observed, that when we let in rel
gious considerations, we often let in light upon the di
ficulties of nature. So in the fact now to be accounte
for, the *degree* of happiness which we usually enjo
in this life may be better suited to a state of trial an
probation than a greater degree would be. The trut
is, we are rather too much delighted with the worl
than too little. Imperfect, broken, and precarious a
our pleasures are, they are more than sufficient to at

ich us to the eager pursuit of them. A regard to a *future* state can hardly keep its place as it is. If we vere designed therefore to be influenced by that re- ard, might not a more indulgent system, a higher or nore uninterrupted state of gratification, have inter- ered with the design? At least it seems expedient hat mankind should be susceptible of this influence, vhen presented to them; that the condition of the vorld should not be such as to exclude its operation, r even to weaken it more than it does. In a religious iew (however we may complain of them in every ther) privation, disappointment, and satiety are not vithout the most salutary tendencies.

CHAPTER XXVII.

CONCLUSION.

In all cases wherein the mind feels itself in danger f being confounded by variety, it is sure to rest upon few strong points, or perhaps upon a single instance. mongst a multitude of proofs, it is *one* that does the usiness. If we observe in any argument, that hardly vo minds fix upon the same instance, the diversity f choice shows the strength of the argument, because shows the number and competition of the examples. 'here is no subject in which the tendency to dwell upon select or single topics is so usual, because ther is no subject, of which, in its full extent, the latitude i so great, as that of natural history applied to the proo of an intelligent Creator. For my part, I take my stand in human anatomy; and the examples of me chanism I should be apt to draw out from the copiou catalogue which it supplies, are the pivot upon whicl the head turns, the ligaments within the socket of th hip-joint, the pulley or trochlear muscles of the eye the epiglottis, the bandages which tie down the ten dons of the wrist and instep, the slit or perforatec muscles at the hands and feet, the knitting of the in testines to the mesentery, the course of the chyle int the blood, and the constitution of the sexes as extend ed throughout the whole of the animal creation. T these instances the reader's memory will go back, a they are severally set forth in their places: there i not one of the number which I do not think decisive not one which is not strictly mechanical: nor have read or heard of any solution of these appearances which, in the smallest degree, shakes the conclusior that we build upon them.

But, of the greatest part of those, who, either in thi book or any other, read arguments to prove the exist ence of a God, it will be said, that they leave off only where they began; that they were never ignorant o this great truth, never doubted of it; that it does no therefore appear, what is gained by researches from which no new opinion is learned, and upon the sub ject of which no proofs were wanted. Now I answe that, by *investigation*, the following points are alway ined, in favor of doctrines even the most generally knowledged, (supposing them to be true,) viz. stabiy and impression. Occasions will arise to try the mness of our most habitual opinions. And upon ese occasions, it is a matter of incalculable use to el our foundation; to find a support in argument for hat we had taken up upon authority. In the present se, the arguments upon which the conclusion rests e exactly such, as a truth of universal concern ought rest upon. "They are sufficiently open to the views d capacities of the unlearned, at the same time that ey acquire new strength and lustre from the discoeries of the learned." If they had been altogether abruse and recondite, they would not have found their ay to the understandings of the mass of mankind; they had been merely popular, they might have anted solidity.

But, secondly, what is gained by research in the ability of our conclusion, is also gained from it in *npression.* Physicians tell us, that there is a great eal of difference between taking a medicine, and the edicine getting into the constitution. A difference ot unlike which obtains with respect to those great oral propositions which ought to form the directing rinciples of human conduct. It is one thing to assent a proposition of this sort; another, and a very diferent thing, to have properly imbibed its influence. I ke the case to be this: perhaps almost every man ving has a particular train of thought, into which his ind glides and falls, when at leisure from the imressions and ideas that occasionally excite it: perhaps, also, the train of thought, here spoken of, mor than any other thing, determines the character. It i of the utmost consequence, therefore, that this proper ty of our constitution be well regulated. Now it is b frequent or continued meditation upon a subject, b placing a subject in different points of view, by induc tion of particulars, by variety of examples, by apply ing principles to the solution of phenomena, by dwel ing upon proofs and consequences, that mental exe cise is drawn into any particular channel. It is b these means, at least, that we have any power over i The train of spontaneous thought, and the choice o that train, may be directed to different ends, and ma appear to be more or less judiciously fixed, accordin to the purpose in respect of which we consider it: bu in a *moral view*, I shall not, I believe, be contradicte when I say, that, if one train of thinking be more de sirable than another, it is that which regards the phe nomena of nature with a constant reference to a su preme intelligent Author. To have made this the ru ing, the habitual sentiment of our minds, is to hav laid the foundation of every thing which is religiou The world thenceforth becomes a temple, and li itself one continued act of adoration. The change i no less than this; that, whereas, formerly God was se dom in our thoughts, we can now scarcely look upo any thing without perceiving its relation to him. Ever organized natural body, in the provisions which it con tains for its sustentation and propagation, testifies care, on the part of the Creator, expressly directed t these purposes. We are on all sides surrounded b uch bodies; examined in their parts, wonderfully cu-ious; compared with one another, no less wonderful-y diversified. So that the mind, as well as the eye, nay either expatiate in variety and multitude, or fix self down to the investigation of particular divisions f the science. And in either case it will rise up from s occupation, possessed by the subject, in a very dif-erent manner, and with a very different degree of in-uence, from what a mere assent to any verbal pro-osition which can be formed concerning the existence f the Deity, at least that merely complying assent ith which those about us are satisfied, and with hich we are too apt to satisfy ourselves, will or can roduce upon the thoughts. More especially may this ifference be perceived in the degree of admiration and f awe, with which the Divinity is regarded, when re-resented to the understanding by its own remarks, its wn reflections, and its own reasonings, compared ith what is excited by any language that can be used y others. The works of nature want only to be con-emplated. When contemplated, they have every thing n them which can astonish by their greatness: for, f the vast scale of operation through which our dis-overies carry us, at one end we see an intelligent ower arranging planetary systems, fixing, for in-ance, the trajectory of *Saturn*, or constructing a ring f two hundred thousand miles diameter, to surround is body, and be suspended like a magnificent arch ver the heads of his inhabitants; and, at the other, ending a hooked tooth, concerting and providing an ppropriate mechanism, for the clasping and reclasp-ing of the filaments of the feather of the humming-bird. We have proof, not only of both these works proceeding from an intelligent agent, but of their proceeding from the same agent: for, in the first place, we can trace an identity of plan, a connection of system, from Saturn to our own globe; and when arrived upon our globe, we can, in the second place, pursue the connection through all the organized, especially the animated, bodies which it supports. We can observe marks of a common relation, as well to one another as to the elements of which their habitation is composed. Therefore one mind hath planned, or at least hath prescribed, a general plan for all these productions. One Being has been concerned in all.

Under this stupendous Being we live. Our happiness, our existence, is in his hand. All we expect must come from him. Nor ought we to feel our situation insecure. In every nature, and in every portion of nature, which we can descry, we find attention bestowed upon even the minutest parts. The hinges in the wings of an *ear-wig*, and the joints of its antennæ, are as highly wrought as if the Creator had had nothing else to finish. We see no signs of diminution of care by multiplicity of objects, or of distraction of thought by variety. We have no reason to fear, therefore, our being forgotten, or overlooked, or neglected.

The existence and character of the Deity is, in every view, the most interesting of all human speculations. In none, however, is it more so, than as it facilitates the belief of the fundamental articles of *Revelation*. It is a step to have it proved, that there mus be something in the world more than what we see. It is a further step to know, that, amongst the invisible things of nature, there must be an intelligent mind concerned in its production, order and support. These points being assured to us by Natural Theology, we may well leave to Revelation the disclosure of many particulars which our researches cannot reach respecting either the nature of this Being as the original cause of all things, or his character and designs as a moral governor; and not only so, but the more full confirmation of other particulars, of which, though they do not lie altogether beyond our reasonings and our probabilities, the certainty is by no means equal to the importance. The true theist will be the first to listen to *any* credible communication of Divine knowledge. Nothing which he has learnt from Natural Theology will diminish his desire of further instruction, or his disposition to receive it with humility and thankfulness. He wishes for light: he rejoices in light. His inward veneration of this great Being will incline him to attend with the utmost seriousness, not only to all that can be discovered concerning him by researches into nature, but to all that is taught by a revelation which gives reasonable proof of having proceeded from him.

But, above every other article of revealed religion, does the anterior belief of a Deity bear with the strongest force upon that grand point, which gives indeed interest and importance to all the rest—the resurrection of the human dead. The thing might appear hopeless, did we not see a power at work adequate to the effect, a power under the guidance of an intelligent will, and a power penetrating the inmost recesses of all substance. I am far from justifying the opinion of those who "thought it a thing incredible that God should raise the dead:" but I admit that it is first necessary to be persuaded that there *is* a God to do so. This being thoroughly settled in our minds, there seems to be nothing in this process (concealed as we confess it to be) which need to shock our belief. They who have taken up the opinion that the acts of the human mind depend upon *organization*, that the mind itself indeed consists in organization, are supposed to find a greater difficulty than others do in admitting a transition by death to a new state of sentient existence, because the old organization is apparently dissolved. But I do not see that any impracticability need be apprehended even by these; or that the change, even upon their hypothesis, is far removed from the analogy of some other operations which we know with certainty that the Deity is carrying on. In the ordinary derivation of plants and animals from one another, a particle, in many cases, minuter than all assignable, all conceivable dimension—an aura, an effluvium, an infinitesimal—determines the organization of a future body: does no less than fix, whether that which is about to be produced shall be a vegetable, a merely sentient, or a rational being; an oak, a frog, or a philosopher; makes all these differences; gives to the future body its qualities, and nature, and species. And this particle, from which springs, and by which is determined, a whole future nature, itself proceeds from, and owes its constitution to, a prior body: nevertheless, which is seen in plants most decisively, the incepted organization, though formed within, and through, and by, a preceding organization, is not corrupted by its corruption, or destroyed by its dissolution; but, on the contrary, is sometimes extricated and developed by those very causes; survives and comes into action when the purpose for which it was prepared requires its use. Now an economy which nature has adopted, when the purpose was to transfer an organization from one individual to another, may have something analogous to it when the purpose is to transmit an organization from one state of being to another state: and they who found thought in organization may see something in this analogy applicable to their difficulties; for, whatever can transmit a similarity of organization will answer their purpose, because, according even to their own theory, it may be the vehicle of consciousness, and because consciousness carries identity and individuality along with it through all changes of form or of visible qualities. In the most general case, that, as we have said, of the derivation of plants and animals from one another, the latent organization is either itself similar to the old organization, or has the power of communicating to new matter the old organic form. But it is not restricted to this rule. There are other cases, especially in the progress of insect life, in which the dormant organization does not much resemble that which incloses it, and still less suits with the situation in which the inclosing body is placed, but suits with a different situation to which it is destined. In the larva of the libellula, which lives constantly, and has still long to live under water, are descried the wings of a fly, which two years afterwards is to mount into the air. Is there nothing in this analogy? It serves at least to show, that, even in the observable course of nature, organizations are formed one beneath another; and, amongst a thousand other instances, it shows completely that the Deity can mould and fashion the parts of material nature so as to fulfil any purpose whatever which he is pleased to appoint.

They who refer the operations of mind to a substance totally and essentially different from matter, (as most certainly these operations, though affected by material causes, hold very little affinity to any properties of matter with which we are acquainted,) adopt perhaps a juster reasoning and a better philosophy: and by these the considerations above suggested are not wanted, at least in the same degree. But to such as find, which some persons do find, an insuperable difficulty in shaking off an adherence to those analogies which the corporeal world is continually suggesting to their thoughts; to such I say, every consideration will be a relief which manifests the extent of that intelligent power which is acting in nature, the fruitfulness of its resources, the variety, and aptness, and success of its means; most especially every consideration which tends to show that, in the translation of a conscious existence, there is not, even in their own way of regarding it, any thing greatly beyond or totally unlike, what takes place in such parts (pro bably small parts) of the order of nature as are accessible to our observation.

Again; if there be those who think that the contractedness and debility of the human faculties in our present state seem ill to accord with the high destinies which the expectations of religion point out to us; I would only ask them, whether any one, who saw a child two hours after its birth, could suppose that it would ever come to understand *fluxions;** or who then shall say, what further amplification of intellectual powers, what accession of knowledge, what advance and improvement, the rational faculty, be its constitution what it will, may not admit of when placed amidst new objects, and endowed with a sensorium adapted, as it undoubtedly will be, and as our present senses are, to the perception of those substances, and of those properties of things, with which our concern may lie.

Upon the whole; in every thing which respects this awful, but, as we trust, glorious change, we have a wise and powerful Being, (the author, in nature, of infinitely various expedients for infinitely various ends,) upon whom to rely for the choice and appointment of means adequate to the execution of any plan which his goodness or his justice may have formed for the moral and accountable part of his terrestrial creation. That great office rests with *him;* be it *ours* to hope and to prepare, under a firm and settled persuasion,

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* See Search's Light of Nature, *passim.*

that, living and dying, we are his; that life is passed in his constant presence, that death resigns us to his merciful disposal.

THE END.

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