Daniel Dewey's

NATURAL THEOLOGY:

OR,

EVIDENCES

OF THE

EXISTENCE AND ATTRIBUTES

OF

THE DEITY,

COLLECTED FROM THE APPEARANCES OF NATURE.

BY WILLIAM PALEY, D. D.

ARCH-DEACON OF CARLISLE.

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1803.

TO

THE RIGHT HONORABLE AND RIGHT REVEREND

SHUTE BARRINGTON, LL.D.

LORD BISHOP OF DURHAM.

MY LORD,

The following Work was undertaken at your Lordship's recommendation; and, amongst other motives, for the purpose of making the most acceptable return I could make for a great and important benefit conferred upon me.

It may be unnecessary, yet not, perhaps, quite impertinent, to state to your Lordship and to the reader, the several inducements that have led me once more to the press. The favor of my first and ever honored patron had put me in possession of so liberal a provision in the church, as abundantly to satisfy my wants, and much to exceed my pretensions. Your Lordship's munificence, in conjunction with that of some other excellent Prelates, who regarded my services with the partiality with which your Lordship was pleased to consider them, hath since placed me in ecclesiastical situations, more than adequate to every object of reasonable ambition. In the mean time, a weak, and, of late, a painful state of health, deprived me of the power of discharging the duties of my station, in a manner at all suitable, either to my sense of those duties, or to my most anxious wishes concerning them. My inability for the public functions of my profession, amongst other consequences, left me much at leisure. That leisure was not to be lost. It was only in my study that I could repair my deficiencies in the *church. It was only through the press that I could speak. These circumstances, in particular, entitled your Lordship to call upon me for the only species of exertion of which I was capable, and disposed me, without hesitation, to obey the call in the best manner that I could. In the choice of a subject I had no place left for doubt: in saying which, I do not so much refer, either to the supreme importance of the subject, or to any scepticism concerning it with which the present times are charged, as I do, to its connexion with the subjects treated of in my former publications. The following discussion alone was wanted to make up my works into a system: in which works, such as they are, the public have now before them, the evidences of natural religion, the evidences of revealed religion, and an account of the duties that result from both. It is of small importance, that they have been written in an order, the very reverse of that in which they ought to be read. I commend therefore the present volume to your Lordship's protection, not only as, in all probability, my last labor, but as the completion of a consistent and comprehensive design.*

Hitherto, My Lord, I have been speaking of myself and not of my Patron. Your Lordship wants not the testimony of a dedication; nor any testimony from me: I consult therefore the impulse of my own mind alone when I declare, that in no respect has my intercourse with your Lordship been more gratifying to me, than in the opportunities, which it has afforded me, of observing your earnest, active, and unwearied solicitude, for the advancement of substantial Christianity; a solicitude, nevertheless, accompanied with that candor of mind, which suffers no subordinate differences of opinion, when there is a coincidence in the main intention and object, to produce any alienation of esteem, or diminution of favor. It is fortunate for a country, and honorable to its government, when qualities and dis-

positions like these are placed in high and influencing stations. Such is the sincere judgment which I have formed of your Lordship's character, and of its public value: my personal obligations I can never forget. Under a due sense of both these considerations, I beg leave to subscribe myself, with great respect and gratitude,

MY LORD,

Your Lordship's faithful
And most devoted servant,

WILLIAM PALEY.

Bishop Wearmouth,
July, 1802.

TABLE OF CONTENTS.

NATURAL THEOLOGY;

OR,

EVIDENCES OF THE EXISTENCE AND ATTRIBUTES OF THE DEITY, COLLECTED FROM THE APPEARANCES OF NATURE.

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 shew the absurdity of this answer. But suppose I had found a *watch* upon the ground, and it should be enquired 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 several parts had been differently shaped from what they are, of a different size 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 percieve 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 respects, 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 shew 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 connection 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 we 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 enquiry 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 watch-maker.

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 phænomena, 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 laths, files, and other tools, evidently and ſeparately calculated for this purpoſe; let us enquire, 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 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 any wiſe 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 colour 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 an 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 an 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 further back, i. e. by supposing the watch before us to have been produced by 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 further 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 indefinite. 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: 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 unorganiſed unmechaniſed, ſubſtance, without mark or indication of contrivance. It might be difficult to ſhew that ſuch ſubſtance could not have exiſted from eternity, either in ſucceſſion (if it were poſſible, which I think it is not, for unorganiſed 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 we 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 adapting 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 an use (all 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 alledge that a series may be carried back to infinity; for I do not admit that we have yet any cause at all of the phænomena, 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, laths, 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 the watch, of its works, construction, and movement suggested, was, that it must have had, for the cause and author of that construction, an artificer, who understood its mechanism, and designed its use. This conclusion is invincible. A *second* examination presents us with a new discovery. The watch is found, in the course of its movement, to produce another watch, similar to itself: and not only so, but we perceive in it a system of organization, separately calculated for that purpose. What effect would this discovery have, or ought it to have, upon our former inference? What, as hath already been said, but to increase, beyond measure, our admiration of the skill, which had been employed in the formation of such a machine? Or shall it, instead of this, all at once turn us round to an opposite conclusion, viz. that no art or skill whatever has been concerned in the business, although all other evidences of art and skill remain as they were, and this last and supreme piece of art be now added to the rest? Can this be maintained without absurdity? Yet this is atheism.

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, subtlety, 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 precifely the fame proof that the eye was made for vifion, as there is that the telefcope was made for affifting it. They are made upon the fame principles; both being adjufted to the laws by which the tranfmiffion and refraction of rays of light are regulated. I fpeak not of the origin of the laws themfelves; but, fuch laws being fixed, the conftruction, in both cafes, is adapted to them. For inftance; thefe laws require, in order to produce the fame effect, that the rays of light, in paffing from water into the eye, fhould be refracted by a more convex furface, than when it paffes out of air into the eye. Accordingly we find, that the eye of a fifh, in that part of it called the cryftalline lenfe, is much rounder than the eye of terreftrial animals. What plainer manifeftation of defign can there be than this difference? What could a mathematical inftrument-maker have done more, to fhew his knowledge of his principle, his application of that knowledge, his fuiting of his means to his end; I will not fay to difplay the compafs or excellency of his fkill and art, for in thefe all comparifon is indecorous, but to teftify counfel, choice, confideration, purpofe?

To fome it may appear a difference fufficient to deftroy all fimilitude between the eye and the telefcope, that the one is a perceiving organ, the other an unperceiving inftrument. The fact is, that they are both inftruments. And, as to the mechanifm, at leaft as to mechanifm being employed, and even as to the kind of it, this circumftance varies not the analogy at all. For obferve, what the conftitution of the eye is. It is neceffary, in order to produce diftinct vifion, that an image or picture of the object be formed at the bottom of the eye. Whence this neceffity arifes, or how the picture is connected with the fenfation, or contributes to it, it may be difficult, nay we will confefs, if you pleafe, impoffible for us to fearch out.—

But the prefent queftion is not concerned in the enquiry. It may be true, that, in this, and in other inftances, we trace mechanical contrivance a certain way; and that then we come to fomething which is not mechanical, or which is infcrutable. But this affects not the certainty of our inveftigation, as far as we have gone. The difference between an animal and an automatic ftatue, confifts in this,—that, in the animal, we trace the mechanifm to a certain point, and then we are ftopped; either the mechanifm becoming too fubtile for our difcernment, or fomething elfe befide the known laws of mechanifm taking place; whereas, in the automaton, for the comparatively few motions of which it is capable, we trace the mechanifm throughout. But, up to the limit, the reafoning is as clear and certain in the one cafe as the other. In the example before us, it is a matter of certainty, becaufe it is a matter which experience and obfervation demonftrate, that the formation of an image at the bottom of the eye is neceffary to perfect vifion. The image itfelf can be fhewn. Whatever affects the diftinctnefs of the image, affects the diftinctnefs of the vifion. The formation then of fuch an image being neceffary (no matter how,) to the fenfe of fight, and to the exercife of that fenfe, the apparatus by which it is formed is conftructed and put together, not only with infinitely more art, but upon the felf-fame principles of art, as in the telefcope or the camera obfcura. The perception arifing from the image may be laid out of the queftion: for the production of the image, thefe are inftruments of the fame kind. The end is the fame; the means are the fame. The purpofe in both is alike; the contrivance for accomplifhing that purpofe is in both alike. The lenfes of the telefcope, and the humours of the eye bear a complete refemblance to one another, in their figure, their pofition, and in their power over the rays of light, viz. in bringing each pencil to a point at the right diſtance from the lenſe; 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 colours, 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 enquire 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 together lenſes compoſed of different ſubſtances, i. e. of ſubſtances which poſſeſſed different refracting powers Our artiſt borrowed from thence his hint; and produced a correction of the defect by imitating, in glaſſes made from different materials, the effects of the different humours 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, 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 further 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 were 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 lenſe to do it. The point of concourſe behind the lenſe muſt fall critically upon the retina, or the viſion is confuſed; yet, 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 lenſe or his teleſcope; or by adjuſting the diſtance of his glaſſes with his hand or his ſcrew: but how is it 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 enquiry 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 cryſtaline lenſe underneath is puſhed forwards; 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 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 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 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, upon occaſion, the cryſtalline lenſe *back*, and ſo 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 obferved upon the figure of the cryftalline compenfating by its roundnefs the denfity of the medium through which their light paffes. To which we have to add, that the eyes of fifh, in their natural and indolent ftate, appear to be adjufted to near objects, in this refpect differing from the human eye, as well as thofe of quadrupeds and birds. The ordinary fhape of the fifh's eye being in a much higher degree convex than that of land animals, a correfponding difference attends its mufcular conformation, viz. that it is throughout calculated for *flattening* the eye.

The iris alfo in the eyes of fifh does not admit of contraction. This is a great difference, of which the probable reafon is, that the diminifhed light in water is never too ftrong for the retina.

In the eel, which has to work its head through fand and gravel, the roughest and harfheft fubftances, there is placed before the eye, and at fome diftance from it, a tranfparent, horny, convex cafe or covering, which, without obftructing the fight, defends the organ. To fuch an animal, could any thing be more wanted, or more ufeful?

Thus, in comparing together the eyes of different kinds of animals, we fee, in their refemblances and diftinction, 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 leaft 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 fide; not in the point where the axis of the eye meets the retina, but between that point and the nofe.—The difference which this makes is, that

* The eye of the feal or fea calf, I underftand, is an exception. Mem. Acad. Paris, 1701, p. 123.

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 subtility 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, colours. The prospect from Hampstead-Hill is compressed into the compass of a six-pence, yet circumstantially represented. A stage coach travelling at its 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. Beside that conformity to optical principles which its internal constitution displays, and which alone amounts to a manifestation of intelligence having been exerted in its structure; beside 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, and 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

* Heister, sect. 89.

edges. In ſome few ſpecies, as that of the coatimondi*, the orbit is not bone throughout; but whenever this is the caſe, the upper, which is the deficient part, is ſupplied by a cartilaginous ligament; a ſubſtitution which ſhews the ſame care. Within this ſocket it is imbedded 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 thoſe which this organ fulfills; 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,

* Mem. R. Ac. Paris, p. 117.

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; bu could the want of the eye generate the gland which produces the tear, or bore the hole by which it is diſcharged—a hole thro' 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 lachrymal humour; 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 different 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, 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 ou 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 eye; this tendon or thread, though ſtrong, is ſo fine, as not to obſtruct the ſight, even when it paſſes acroſs it; and the muſcle itſelf being placed in the *back* part of the eye, derives from its ſituation the advantage, not only of being ſecure, but of being out of the way; which it would hardly have been in any poſition that could be aſſigned to it in the anterior part of the orb, where its function lies. When the muſcle behind the eye contracts, the membrane, by means of the communicating thread, is inſtantly drawn over the fore part of it. When the muſcular contraction (which is a poſitive, and, moſt probably, a voluntary effort,) ceaſes to be exerted, the elaſticity alone of the membrane brings it back again to its poſition.* Does not this, if any thing can do it, beſpeak an artiſt, maſter of his work, acquainted with his materials? "Of a thouſand other things," ſay the French Academicians, "we perceive not the contrivance, becauſe we underſtand them only by the effects, of which we know not the cauſes; but we here treat of a machine, all the parts whereof are viſible; and which need only be looked upon to diſcover the reaſons of its motion and action."†

In the configuration of the muſcle, which, though 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 pulley. This is a peculiarity; and obſerve the ad-

* Phil. Tranſ. 1796.

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

vantage 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 cord of the main muſcle makes an angle. This, ſo far, anſwered 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 means? an element provided for the purpoſe; reflected from opaque ſubſtances, refracted thro' tranſparent ones; and both according to preciſe laws: then, a complex organ, an intricate and artificial apparatus, in order, by the operation of this element, and in conformity with the reſtrictions of theſe laws, to produce an image upon a membrane communicating with the brain? Wherefore all this? Why make the difficulty in order only to ſurmount it? If to perceive objects by ſome other mode than that of touch, or objects which lay out of the reach of that ſenſe, were the thing purpoſed, could not a ſimple volition of the Creator have communicated the capacity? Why reſort to contrivance, where power is omnipotent? Contrivance, by its very definition and nature, is the refuge of imperfection. To have recourſe to expedients, implies difficulty, impediment, reftraint, defect of power. This queftion belongs to the other fenfes, as well as to fight; to the general functions of animal life, as nutrition, fecretion, refpiration; to the œconomy of vegetables; and indeed to almoft all the operations of nature. The queftion therefore is of very wide extent; and, amongft other anfwers which may be given to it, befide reafons of which probably we are ignorant, one anfwer is this. It is only by the difplay of contrivance, that the exiftence, the agency, the wifdom of the Deity, *could* be teftified to his rational creatures. This is the fcale by which we afcend to all the knowledge of our Creator which we poffefs, fo far as it depends upon the phænomena, or the works of nature. Take away this, and you take away from us every fubject of obfervation, and ground of reafoning; I mean as our rational faculties are formed at prefent. Whatever is done, God could have done, without the intervention of inftruments or means: but it is in the conftruction of inftruments, in the choice and adaptation of means, that a creative intelligence is feen. It is this which conftitutes the order and beauty of the univerfe. God, therefore, has been pleafed to prefcribe limits to his own power, and to work his ends within thofe limits. The general laws of matter have perhaps the nature of thefe limits; its inertia, its re-action; the laws which govern the communication of motion, the refraction and reflection of light, the conftitution of fluids non-elaftic and elaftic, the tranfmiffion of found through the latter; the laws of magnetifm, of electricity; and probably others yet undifcovered. Thefe are general laws; and when a particular purpofe is to be effected, it is not by making a new law, nor by the fufpenfion of the old ones, nor by making them wind and bend and yield to the occafion (for nature with great fteadinefs adheres to, and fupports them,) but it is, as we have feen in the eye, by the interpofition of an apparatus, correfponding with thefe laws, and fuited to the exigency which refults from them, that the purpofe is at length attained. As we have faid, therefore, God prefcribes limits to his power, that he may let in the exercife, and thereby exhibit demonftrations of his wifdom. For then, i. e. fuch laws and limitations being laid down, it is as though one Being fhould have fixed certain rules; and, if we may fo fpeak, provided certain materials; and, afterwards, have committed to another Being, out of thefe materials, and in fubordination to thefe rules, the tafk of drawing forth a creation: a fuppofition which evidently leaves room, and induces indeed a neceffity, for contrivance. Nay, there may be many fuch agents, and many ranks of thefe. We do not advance this as a doctrine either of philofophy or of religion; but we fay that the fubject may fafely be reprefented under this view, becaufe the Deity, acting himfelf by general laws, will have the fame confequences upon our reafoning, as if he had prefcribed thefe laws to another. It has been faid, that the problem of creation was, "attraction and matter being given, to make a world out of them:" and, as above explained, this ftatement perhaps does not convey a falfe idea.

We have made choice of the eye as an inftance upon which to reft the argument of this chapter. Some fingle example was to be propofed; and the eye offered itfelf under the advantage of admitting of a ftrict comparifon with optical inftruments. The ear, it is probable, is no lefs artificially and mechanically adapted to its office, than the eye; but we know lefs about it: we do not fo well underftand the action, the ufe, or the mutual dependency of its internal parts. Its general form, however, both external and internal, is sufficient to shew that it is an instrument adapted to the reception of sound; that is to say, already knowing that sound consists in pulses of the air, we perceive, in the structure of the ear, a suitableness to receive impressions from this species of action, and to propagate these impressions to the brain. For, of what does this structure consist? An external ear, (the concha) calculated, like an ear-trumpet, to catch and collect the pulses of which we have spoken; in large quadrupeds, turning to the sound, and possessing a configuration, as well as motion, evidently fitted for the office: of a tube which leads into the head, lying at the root of this outward ear, the folds and sinuses thereof tending and conducting the air towards it: of a thin membrane, like the pelt of a drum, stretched across this passage upon a bony rim: of a chain of moveable, and infinitely curious, bones, forming a communication, and the only communication that can be observed, between the membrane last mentioned, and the interior channels and recesses of the skull: of cavities, similar in shape and form to wind instruments of music, being spiral or portions of circles: of the eustachian tube, like the hole in a drum, to let the air pass freely into and out of the barrel of the ear, as the covering membrane vibrates, or as the temperature may be altered: the whole labyrinth hewn out of a rock: that is, wrought into the substance of the hardest bone in the body. This assemblage of connected parts constitutes together an apparatus, plainly enough relative to the transmission of sound, or of the impulses received from sound, and only to be lamented in not being better understood.

The communication within, formed by the small bones of the ear, is, to look upon, more like what we are accustomed to call machinery, than any thing I am acquainted with in animal bodies. It ſeems evidently deſigned to continue towards the ſenſorium the tremulous motions which are excited in the " membrane of the tympanum," or what is better known by the name of the " drum of the ear." The compages of bones conſiſts of four, which are ſo diſpoſed, and ſo hinge upon one another, as that, if the membrane, the drum of the ear, vibrate, all the four parts are put in motion together; and, by the reſult of their action, work the baſe of that which is the laſt in the ſeries, upon an aperture which it cloſes, and upon which it plays, and which aperture opens into the tortuous canals that lead to the brain. This laſt bone of the four is called the ſtapes. The office of the drum of the ear is to ſpread out an extended ſurface, capable of receiving the impreſſions of ſound, and of being put by them into a ſtate of vibration. The office of the ſtapes is to repeat theſe vibrations. It is a repeating frigate, ſtationed more within the line. From which account of its action may be underſtood, how the ſenſation of ſound will be excited, by any thing which communicates a vibratory motion to the ſtapes, though not, as in all ordinary caſes, through the intervention of the membrana tympani. This is done by ſolid bodies applied to the bones of the ſkull, as by a metal bar held at one end between the teeth, and touching at the other end a tremulous body. It likewiſe appears to be done, in a conſiderable degree, by the air itſelf, even when this membrane, the drum of the ear, is greatly damaged. Either in the natural or præternatural ſtate of the organ, the uſe of the chain of bones is to propagate the impulſe in a direction towards the brain, and to propagate it with the advantage of a lever; which advantage conſiſts in increaſing the force and ſtrength of the vibration, and at the ſame time diminiſhing the ſpace through which it oſcillates: both of which changes may augment or facilitate the ſtill deeper action of the auditory nerves.

The benefit of the euſtachian tube to the organ, may be made out upon known 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 aſſigned 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 not 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 Philoſophical Tranſactions for the year 1800, (vol. i) 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 radiated 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 ſuppoſes to be deſigned to bring the membrane into uniſon with different ſounds: but then he alſo diſcovered, that this muſcle itſelf cannot act, unleſs the membrane be drawn to a ſtretch, and kept in a due ſtate of tightneſs, by what may be called a foreign force, viz. the action of the muſcles of the malleus. Our author, ſuppoſing his explanation of the uſe of the parts to be juſt, 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 connexion 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.

OF 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 a preceding chapter, the production of a watch by the motion and mechaniſm of a former watch, would account for the ſkill and intention 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 connexion, 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 incloses 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 animals; from seeds to eggs. Now I say, that 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 plane 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 higest; 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 parent that any such account can be drawn. He is the cause of his offspring in the same sense as that in which a gardener is the cause of the tulip which grows upon 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 observe a provision for its nourishment, growth, protection, and fecundity: but we never think of the gardener in all this We attribute nothing of this to his agency; yet it may still be true, that, without the gardener, we should not have had the tulip. Just so is it with the succesſion of animals even of the higheſt order. For the contrivance diſcovered in the ſtructure of the thing produced, we want a contriver. The parent is not that contriver. His conſciouſneſs decides that queſtion. He is in total ignorance why that which is produced took its preſent form rather than any other. It is for him only to be aſtoniſhed by the effect. We can no more look therefore to the intelligence of the parent animal for what we are in ſearch of, a cauſe of relation and of ſubſerviency of parts to their uſe, which relation and ſubſerviency we ſee in the procreated body, than we can refer the internal conformation of an acorn to the intelligence of the oak from which it dropped, or the ſtructure of the watch to the intelligence of the watch which produced it; there being no difference, as far as argument is concerned, between an intelligence which is not exerted, and an intelligence 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 enquiring 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 the 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 enquirer, 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 likely to happen, they be unknown and unperceived by him. This we must do in order to vindicate the artist's skill, or, at least, the perfection of it; as we must also judge of his intention, and of the provisions employed in fulfilling that intention, not from an instance in which they fail, but from the great plurality of instances in which they succeed. But, after all, these are different questions from the question of the artist's existence; or, which is the same, whether the thing before us be a work of art or not: and the questions ought always to be kept separate in the mind. So likewise it is in the works of nature. Irregularities and imperfections are of little or no weight in the consideration, when that consideration relates simply to the existence of a Creator. When the argument respects his attributes, they are of weight; but are then to be taken in conjunction (the attention is not to rest upon them, but they are to be taken in conjunction) with the 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, as to induce us, upon the moſt reaſonable ground, to believe, that theſe laſt ought to be referred to ſome cauſe, though we be ignorant of it, other than defect of 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 is 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 œconomy 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 functions. 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 with the number of those, of which the use is evident, they are beneath any assignable proportion; and, perhaps, have never been submitted to a trial and examination sufficiently accurate, long enough continued, or often enough repeated. No accounts which I have seen are satisfactory. The mutilated animal may live and grow 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 vigour and perfection, be performed, or how long preserved, without the extirpated organ, does not seem to be ascertained by experiment. But to this case, even were it fully made out, may be applied the consideration which we suggested concerning the watch, viz. that these superfluous parts do not negative the reasoning which we instituted concerning those parts which are useful, and of which we know the use. The indication of contrivance, with respect to them, remains as it was before.

III. One atheistic way of replying to our observations upon the works of nature, and to the proofs of a Deity which we think that we perceive in them, is to tell us, that all which we see must necessarily have had some form, and that it might as well be its present form as any other. Let us now apply this answer to the eye, as we did before to the watch. Something or other must have occupied that place in the animal's head; must have filled up, we will say, that socket: we will say also, that it must have been of that sort of substance which we call animal substance, as flesh, bone, membrane, 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 bye, 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 of 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, would 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 thoſe points in 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 ſome form or other," is too abſurd to be made more ſo by any argumentation. We are not contented with this anſwer, we find no ſatiſfaction in it, by way of accounting for appearances of organization far ſhort of thoſe of the eye, ſuch as we obſerve in foſſil ſhells, petrified bones, or other ſubſtances which bear the veſtiges of animal or vegetable recrements, but which, either in reſpect of utility, or of the ſituation in which they are diſcovered, may ſeem accidental enough. It is no way of accounting even for theſe things, to ſay that the ſtone, for inſtance, which is ſhewn us, (ſuppoſing the queſtion to be concerning a petrification,) muſt have contained ſome internal conformation or other. Nor does it mend the anſwer to add, with reſpect to the ſingularity of the conformation, that, after the event, it is no longer to be computed what the chances were againſt it. This is always to be computed, when the queſtion is whether an uſeful or imitative conformation be the produce of chance or not. I deſire no greater certainty in reaſoning, than that by which chance is excluded from the preſent diſpoſition of the natural world. Univerſal experience is againſt it. What does chance ever do for us? In the human body, for inſtance, chance, i. e. the operation of cauſes without 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, anſwering a valuable purpoſe by a complicated mechaniſm, 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 relict 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 deliniated 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 alledged that theſe may tranſgreſs the limits 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 is 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 were badly formed, periſhed: but how or why thoſe which ſurvived ſhould be caſt, as we ſee that plants and animals are caſt, into regular claſſes, the hypotheſis does not explain; or rather the hypotheſis is inconſiſtent with this phænomenon.

The hypotheſis, indeed, is hardly deſerving of the conſideration which we have given to it. What ſhould we think of a man, who, becauſe we had never ourſelves ſeen watches, teleſcopes, ſtocking mills, ſteam-engines, &c. made; knew not how they were made; or could prove by teſtimony when they were made, or by whom; would have us believe that theſe machines, inſtead of deriving their curious ſtructures from the thought and deſign of their inventors and contrivers, in truth derive them from no other origin than this; that, a maſs of metals and other materials having run, when melted, into all poſſible figures, and combined themſelves in all poſſible forms and ſhapes and proportions, theſe things which we ſee, are what were left from the accident, as beſt worth preſerving; and, as ſuch, are become the remaining ſtock of a magazine, which, at one time or other, has, by this means, contained every mechaniſm, uſeful and uſeleſs, convenient and inconvenient, into which ſuch like materials could be thrown? I cannot diftinguifh the hypothefis as applied to the works of nature, from this folution, which no one would accept, as applied to a collection of machines.

V. To the marks of contrivance difcoverable in animal bodies, and to the argument deduced from them, in proof of defign, and of a defigning Creator, this turn is fometimes attempted to be given, viz. that the parts were not intended for the ufe, but that the ufe arofe out of the parts. This diftinction is intelligible. A cabinet-maker rubs his mahogany with fifh-fkin; yet it would be too much to affert that the fkin of the dog fifh was made rough and granulated on purpofe for the polifhing of wood, and the ufe of cabinet-makers. Therefore the diftinction is intelligible. But I think that there is very little place for it in the works of nature. When roundly and generally affirmed of them, as it hath fometimes been, it amounts to fuch another ftretch of affertion, as it would be to fay, that all the implements of the cabinet-maker's workfhop, as well as his fifh-fkin, were fubftances accidentally configurated, which he had picked up, and converted to his ufe; that his adzes, faws, planes, and gimblets, were not made, as we fuppofe, to hew, cut, fmooth, fhape out, or bore wood with; but that, thefe things being made, no matter with what defign, or whether with any, the cabinet-maker perceived that they were applicable to his purpofe, and turned them to account.

But, again; fo far as this folution is attempted to be applied to thofe parts of animals the action of which does not depend upon the will of the animal, it is fraught with ftill more evident abfurdity. Is it poffible to believe that the eye was formed without any regard to vifion; that it was the animal itfelf which found out, that, though formed with no fuch intention, it would ferve to fee with; and that the ufe of the eye, as an organ of fight, refulted from this difcovery, and the animal's application of it? The ſame queſtion may be aſked of the ear; the ſame of all the ſenſes. None of the ſenſes fundamentally depend upon the election of the animal: conſequently neither upon his ſagacity, nor his experience. It is the impreſſion which objects make upon them that conſtitutes their uſe. Under that impreſſion he is paſſive. He may bring objects to the ſenſe, or within its reach; he may ſelect theſe objects; but over the impreſſion itſelf he has no power, or very little; and that properly is the ſenſe.

Secondly, there are many parts of animal bodies which ſeem to depend upon the will of the animal in a greater degree than the ſenſes do, and yet with reſpect to which this ſolution is equally unſatisfactory. If we apply the ſolution to the human body, for inſtance, it forms itſelf into queſtions upon which no reaſonable mind can doubt; ſuch as, whether the teeth were made expreſsly for the maſtication of food, the feet for walking, the hands for holding; or whether, theſe things being as they are, being in fact in the animal's poſſeſſion, his own ingenuity taught him that they were convertible to theſe purpoſes, though no ſuch purpoſes were contemplated in their formation.

All that there is of the appearance of reaſon in this way of conſidering the ſubject is, that, in ſome caſes, the organization ſeems to determine the habits of the animal, and its choice, to a particular mode of life; which, in a certain ſenſe, may be called "the uſe ariſing out of the part." Now to all the inſtances, in which there is any place for this ſuggeſtion, it may be replied, that the organization determines the animal to habits beneficial and ſalutary to itſelf; and that this effect would not be ſeen ſo regularly to follow, if the ſeveral organizations did not bear a concerted and contrived relation to the ſubſtances by which the animal was furrounded. They would, otherwife, be capacities without objects; powers without employment. The web foot determines, you fay, the duck to fwim: but what would that avail, if there were no water to fwim in? The ftrong, hooked bill, and fharp talons, of one fpecies of bird, determine it to prey upon animals; the foft ftraight bill, and weak claws, of another fpecies, determine it to pick up feeds: but neither determination could take effect in providing for the fuftenance of the birds, if animal bodies and vegetable feeds did not lie within their reach. The peculiar conformation of the bill, and tongue, and claws of the woodpecker, determines that bird to fearch for his food amongft the infects lodged behind the bark, or in the wood, of decayed trees; but what would this profit him if there were no trees, no decayed trees, no infects lodged under their bark, or in their trunk? The probofcis with which the bee is furnifhed, determines him to feek for honey; but what would that fignify, if flowers fupplied none? Faculties thrown down upon animals at random, and without reference to the objects amidft which they are placed, would not produce to them the fervices which we fee: and if there be that reference, then there is intention.

Laftly, the folution fails entirely when applied to plants. The parts of plants anfwer their ufes, without any concurrence from the will or choice of the plant.

VI. Others have chofen to refer every thing to a *principle of order* in nature. A principle of order is the word: but what is meant by a principle of order, as different from an intelligent Creator, has not been explained, either by definition or example: and, without fuch explanation, it fhould feem to be a mere fubftitution of words for reafons, names for caufes. Order itfelf is only the adaptation of means to an end:

a principle of order, therefore, can only ſignify the mind and intention which ſo adapts them. Or, were it capable of being explained in any other ſenſe, is there any experience, any analogy, to ſuſtain it? Was a watch ever produced by a principle of order? and why might not a watch be ſo produced, as well as an eye?

Furthermore, a principle of order, acting blindly and without choice, is negatived by the obſervation, that order is not univerſal; which it would be, if it iſſued from a conſtant and neceſſary principle; nor indiſcriminate, which it would be, if it iſſued from an unintelligent principle. Where order is wanted, there we find it; where order is not wanted, i. e. where, if it prevailed, it would be uſeleſs, there we do not find it. In the ſtructure of the eye (for we adhere to our example,) in the figure and poſition of its ſeveral parts, the moſt exact order is maintained. In the forms of rocks and mountains, in the lines which bound the coaſts of continents and iſlands, in the ſhape of bays and promontories, no order whatever is perceived, becauſe it would have been ſuperfluous. No uſeful purpoſe would have ariſen from moulding rocks and mountains into regular ſolids, bounding the channel of the ocean by geometrical curves, or from the map of the world reſembling a table of diagrams in Euclid's Elements, or Simpſon's Conic Sections.

VII. Laſtly, the confidence which we place in our obſervations upon the works of nature, in the marks which we diſcover of contrivance, choice, and deſign, and in our reaſoning upon the proofs afforded us, ought not to be ſhaken, as it is ſometimes attempted to be done, by bringing forward to our view our own ignorance, or rather the general imperfections of our knowledge, of nature. Nor, in many caſes, ought this conſideration to affect us, even when it reſpects ſome parts of the ſubject immediately under our notice.

True fortitude of underſtanding conſiſts in not ſuffering what we know to be diſturbed by what we do not know. If we perceive an uſeful end, and means adapted to that end, we perceive enough for our concluſion. If theſe things be clear, no matter what is obſcure. The argument is finiſhed. For inſtance; if the utility of viſion to the animal which enjoys it, and the adaptation of the *eye* to this office be evident and certain (and I can mention nothing which is more ſo,) ought it to prejudice the inference which we draw from theſe premiſes, that we cannot explain the uſe of the ſpleen? Nay more; if there be parts of the eye, viz. the cornea, the cryſtalline, the retina, in their ſubſtance, figure, and poſition, manifeſtly ſuited to the formation of an image by the refraction of rays of light, at leaſt as manifeſtly as the glaſſes and tubes of a dioptric teleſcope are ſuited to that purpoſe, it concerns not the proof which theſe afford of deſign and of a deſigner, that there may perhaps be other parts, certain muſcles, for inſtance, or nerves, in the ſame eye, of the agency or effect of which we can give no account; any more than we ſhould be inclined to doubt, or ought to doubt, about the conſtruction of a teleſcope, viz. for what purpoſe it was conſtructed, or whether it were conſtructed at all, becauſe there belonged to it certain ſcrews and pins, the uſe or action of which we did not comprehend. I take it to be a general way of infuſing doubts and ſcruples into the mind, to recall to it its own ignorance, its own imbecility; to tell us that upon theſe ſubjects we know little; that little imperfectly; or rather, that we know nothing properly about the matter. Theſe ſuggeſtions ſo fall in with our conſciouſneſſes, as ſometimes to produce a general diſtruſt of our faculties and our concluſions. But this is an unfounded jealouſy. The uncertainty of one thing, does not neceſſarily affect the certainty of another thing. Our ignorance of many points need not ſuſpend our aſſurance of a few. Before we yield, in any particular inſtance, to the ſcepticiſm which this ſort of inſinuation would induce, we ought accurately to aſcertain, whether our ignorance or doubt concern thoſe preciſe points upon which our concluſion reſts. Other points are nothing. Our ignorance of other points may be of no conſequence to theſe; though they be points, in various reſpects, of great importance. A juſt reaſoner removes from his conſideration, not only what he knows, but what he does not know, touching matters not ſtrictly connected with his argument, i. e. not forming the very ſteps of his deduction: beyond theſe, his knowledge and his ignorance are alike irrelative.

CHAPTER VI.

THE ARGUMENT CUMULATIVE.

WERE there no example in the world of contrivance except that of the *eye*, it would be alone ſufficient to ſupport the concluſion which we draw from it, as to the neceſſity of an intelligent Creator. It could never be got rid of: becauſe it could not be accounted for by any other ſuppoſition, which did not contradict all the principles we poſſeſs of knowledge; the principles according to which, things do, as often as they can be brought to the teſt of experience, turn out to be true or falſe. Its coats and humours, conſtructed, as the lenſes of a teleſcope are conſtructed, for the refraction of rays of light to a point, which forms the proper action of the organ; the proviſion in its muſcular tendons for turning its pupil to the object, ſimilar to that which is given to the teleſcope by ſcrews, and upon which power of direction in the eye, the exerciſe of its office, as an optical inſtrument, depends; the further proviſion for its defence, for its conſtant lubricity and moiſture, which we ſee in its ſocket and its lids, in its gland for the ſecretion of the matter of tears, its outlet or communication with the noſe for carrying off the liquid after the eye is waſhed with it; theſe proviſions compoſe altogether an apparatus, a ſyſtem of parts, a preparation of means, ſo manifeſt in their deſign, ſo exquiſite in their contrivance, ſo ſucceſsful in their iſſue, ſo precious and ſo infinitely beneficial in their uſe, as, in my opinion, to bear down all doubt that can 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 enquiries, 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 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 affects 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 shewn, the mind may set itself at rest: no future consideration can detract any thing from the force of the example.

CHAPTER VII.

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

IT is not that *every* part of an animal or vegetable has not proceeded from a contriving mind; or that every part is not constructed with a view to its proper end and purpose, according to the laws belonging to, and governing, the substance or the action made use of in that part; or that each part is not so constructed, as to effectuate its purpose whilst it operates according to these laws: but it is, because these laws themselves are not in all cases equally understood; or, what amounts to nearly the same thing, are not equally exemplified in more simple processes, and more simple machines; that we lay down the distinction, here proposed, between the mechanical parts, and other parts, of animals and vegetables.

For instance; the principle of muscular motion, viz. upon what cause the swelling of the belly of the muscle, and consequent contraction of its tendons, either by an act of the will or by involuntary irritation, depends, is wholly unknown to us. The substance employed, whether it be fluid, gaseous, elastic, electrical, or none of these, or nothing resembling these, is also unknown to us: of course the laws belonging to that ſubſtance, and which regulate its action, are unknown to us. We ſee nothing ſimilar to this contraction in any machine which we can make, or any proceſs which we can execute. So far (it is confeſſed) we are in ignorance: but no further. 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. Suppoſe 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 contraverſy 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 ſhew 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 *chymical* part of our frame; of which, by reason of the imperfection of our chymistry, 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 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 one 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 chymical ſolution which we can produce, or with which we are acquainted, in this reſpect as well as many others, that, in our chymiſtry, 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 chymical 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 chymiſtry; 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 chymical 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 chymistry, 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-chymical 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, colour, 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 fetid odours. 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 œconomy; 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 shewn 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 chymical election, no chymical 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 enquiries. 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 towords the pelvis, which is a baſon 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 fee an organized apparatus, be its conftruction or action what it will, which we call that gland. We fee the blood, or part of the blood, after it has paffed through and undergone the action of the gland, coming *from* it by an emulgent vein or artery, i. e. by another pipe or conduit. And we fee alfo at the fame time, a new and fpecific fluid iffuing from the fame gland by its excretory duct, i. e. by a third pipe or conduit; which new fluid is in fome cafes difcharged out of the body, in more cafes retained within it, and there executing fome important and intelligible office. Now fuppofing, or admitting, that we know nothing of the proper internal conftitution of a gland, or of the mode of its acting upon the blood; then our fituation is precifely like that of an unmechanical looker-on, who ftands by a ftocking-loom, a corn-mill, a carding-machine, or a threfhing-machine at work, the fabric and mechanifm of which, as well as all that paffes within, is hidden from his fight by the outfide cafe; or, if feen, would be too complicated for his uninformed, uninftructed underftanding to comprehend. And what is that fituation? This fpectator, ignorant as he is, fees at one end a material enter the machine, as unground grain the mill, raw cotton the carding-machine, fheaves of unthrefhed corn the threfhing-machine; and, when he cafts his eye to the other end of the apparatus, he fees the material iffuing from it in a new ftate; and, what is more, in a ftate manifeftly adapted to future ufes; the grain in meal fit for the making of bread, the wool in rovings ready for fpinning into threads, the fheaf in corn dreffed for the mill. Is it neceffary that this man, in order to be convinced, that defign, that intention, that contrivance has been employed about the machine, fhould be allowed to pull it in pieces; fhould be enabled to examine the parts feparately; 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 viſitor, to be a mill-right 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 confirmation were wanting to the evidence which the animal ſecretions afford of deſign, it may be derived, as hath 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 referring 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 can compare them with works of art: thirdly, that the mechanical parts of our frame, or, those in which this comparison is most complete, altho' constituting, probably, the coarsest portions of nature's workmanship, are the properest to be alledged as proofs and speciments of design.

CHAPTER VIII.

OF MECHANICAL ARRANGEMENT IN THE HUMAN FRAME.

WE proceed therefore to propose certain examples taken out of this class; making choice of such, as, amongst those which have come to our knowledge, appear to be the most striking, and the best understood; but obliged, perhaps, to postpone both these recommendations to a third, that of the example being capable of explanation without plates or figures, or technical language.

OF THE BONES.

I. I challenge any man to produce, in the joints and pivots of the most complicated, or the most flexible, machine, that was ever contrived, a construction more artificial, or more evidently artificial, than that which is seen in the vertebræ of the *human neck*. Two things were to be done. The head was to have the power of bending forward and backward, as in the act of nodding, stooping, looking upward or downward; and, at the same time, of turning itself round upon the body to a certain extent, the quadrant we will say, or rather, perhaps, a hundred and twenty degrees of a circle. For these two purposes, two distinct contrivances are employed. First, the head rests immediately upon the uppermost of the vertebræ, and is united to it by 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 mortice*. This second, or uppermost bone but one, has what anatomist 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 first bone of the neck. When we turn the head round, we use the tenon and mortice, 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 requifite, that the object end of the inftrument be moved up and down, as well as horizontally or equatorially. For the vertical motion there is a hinge upon which the telefcope plays: for the horizontal or equatorial motion, an axis upon which the telefcope and the hinge turn round together. And this is exactly the mechanifm which is applied to the motion of the head: nor will any one here doubt of the exiftence of counfel and defign, except it be by that debility of mind, which can truft to its own reafonings in nothing.

We may add, that it was, on another account alfo, expedient, that the motion of the head backward and forward fhould be performed upon the upper furface of the firft vertebra: for, if the firft vertebra itfelf had bent forward, it would have brought the fpinal marrow, at the very beginning of its courfe, upon the point of the tooth.

II. Another mechanical contrivance, not unlike the laft in its object, but different and original in its means, is feen in what anatomifts call the *fore-arm*: that is, in the arm between the elbow and the wrift. Here, for the perfect ufe 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 occafion requires, may be turned upward. How is this managed? The fore-arm, it is well known, confifts of two bones, lying along-fide each other, but touching only towards the ends. One, and only one, of thefe bones, is joined to the cubit, or upper part of the arm, at the elbow; the other alone, to the hand at the wrift. The firft, by means, at the elbow, of a hinge joint (which allows only of motion in the fame plane,) fwings backward and forward, carrying along with it the other bone, and the whole fore-arm. In the mean time, as often as there is occafion 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 convince himſelf, who puts the eaſe and quickneſs, with which he can ſhake his hand at the wriſt circularly (moving likewiſe, if he pleaſe, 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 reſt upon.

Beſpeak of a workman a piece of mechaniſm which ſhall compriſe all theſe purpoſes, and let him ſet about to contrive it; let him try his ſkill upon it; let him feel the difficulty of accompliſhing the taſk, before he be told how the ſame thing is effected in the animal frame. Nothing will enable him to judge ſo well of the wiſdom which has been employed; nothing will diſpoſe him to think of it ſo truly. Firſt, for the firmneſs, yet flexibility, of the ſpine, it is composed of a great number of bones (in the human subject of twenty-four) joined to one another, and compacted together, by broad bases. The breadth of the bases upon which the parts severally rest, and the closeness of the junction, give to the chain its firmness and stability: the number of parts, and consequent frequency of joints, its flexibility. Which flexibility, we may also observe, varies in different parts of the chain: is least in the back, where strength more than flexure is wanted; greater in the loins, which it was necessary should be more supple than the back; and greatest of all in the neck, for the free motion of the head. Then, secondly, in order to afford a passage for the descent of the medullary substance, each of these bones is bored through in the middle in such a manner, as that, when put together, the hole in one bone falls into a line, and corresponds, with the holes in the two bones contiguous to it. By which means, the perforated pieces, when joined, form an entire, close, uninterrupted channel: at least whilst the spine is upright and at rest. But, as a settled posture is inconsistent with its use, a great difficulty still remained, which was to prevent the vertebræ shifting upon one another, so as to break the line of the canal as often as the body moves or twists; or the joints gaping externally, whenever the body is bent forward, and the spine, thereupon, made to take the form of a bow. These dangers, which are mechanical, are mechanically provided against. The vertebræ, by means of their processes and projections, and of the articulations which some of these form with one another at their extremities, are so locked in and confined, as to maintain, in what are called the bodies or broad surfaces of the bones, the relative position nearly unaltered; and to throw the change and the pressure, produced by flexion, almost entirely upon the intervening cartilages, the springiness and yielding nature of whose ſubſtance admits of all the motion which is neceſſary to be performed upon them, without any chaſm being produced by a ſeparation of the parts. I ſay of all the motion which is neceſſary; for, although we bend our backs to every degree almoſt of inclination, the motion of each vertebra is very ſmall; ſuch is the advantage which we receive from the chain being compoſed of ſo many links, the ſpine of ſo many bones. Had it conſiſted of three or four bones only, in bending the body the ſpinal marrow muſt have been bruiſed at every angle. The reader need not be told that theſe intervening cartilages are griſtles; and he may ſee them in perfection in a loin of veal. Their form alſo favors the ſame intention. They are thicker before than behind, ſo that, when we ſtoop forward, the compreſſible ſubſtance of the cartilage, yielding in its thicker and anterior part to the force which ſqueezes it, brings the ſurfaces of the adjoining vertebræ nearer to the being parallel with one another than they were before, inſtead of increaſing the inclination of their planes, which muſt have occaſioned a fiſſure or opening between them. Thirdly, for the medullary canal giving out in its courſe, and in a convenient order, a ſupply of nerves to different parts of the body, notches are made in the upper and lower edge of every vertebra; two on each edge; equidiſtant on each ſide from the middle line of the back. When the vertebræ are put together, theſe notches, exactly fitting, form ſmall holes; through which the nerves, at each articulation, iſſue out in pairs, in order to ſend their branches to every part of the body, and with an equal bounty to both ſides of the body. The fourth purpoſe aſſigned to the ſame inſtrument, is the inſertion of the baſes of the muſcles, and the ſupport of the ends of the ribs: and for this fourth purpoſe, eſpecially the former part of it, a figure, ſpecifically ſuited to the deſign, and unneceſſary for the other purposes, is given to the constituent bones. Whilst they are plain, and round, and smooth towards the front, where any roughness or projection might have wounded the adjacent viscera, they run out, behind, and on each side, into long processes, to which processes the muscles necessary to the motions of the trunk are fixed; and fixed with such art, that, whilst the vertebræ supply a basis for the muscles, the muscles help to keep these bones in their position, or by their tendons to tie them together.

That most important, however, and general property, viz. the strength of the compages, and the security against luxation, was to be still more specially consulted; for where so many joints were concerned, and where, in every one, derangement would have been fatal, it became a subject of studious precaution. For this purpose, the vertebræ are articulated, that is, the moveable joints between them are formed, by means of those projections of their substance, which we have mentioned under the name of processes; and these so lock in with, and overwrap, one another, as to secure the body of the vertebra, not only from accidentally slipping, but even from being pushed, out of its place, by any violence short of that which would break the bone. I have often remarked and admired this structure in the chine of a hare. In this, as in many instances, a plain observer of the animal œconomy may spare himself the disgust of being present at human dissections, and yet learn enough for his information and satisfaction, by even examining the bones of the animals which come upon his table.— Let him take, for example, into his hands, a piece of the clean-picked bone of a hare's back; consisting, we will suppose, of three vertebræ. He will find the middle bone of the three, so implicated, by means of its projections or processes, with the bone on each side of it, that no pressure which he can use, will force it out of its place between them. It will give way neither forward, nor backward, nor on either side. In whichever direction he pushes, he perceives, in the form, or junction, or overlapping of the bones, an impediment opposed to his attempt; a check and guard against dislocation. In one part of the spine, he will find a still further fortifying expedient, in the mode according to which the ribs are annexed to the spine. Each rib rests upon two vertebræ. That is the thing to be remarked, and any one may remark it in carving a neck of mutton. The manner of it is this: the end of the rib is divided by a middle ridge into two surfaces, which surfaces are joined to the bodies of two contiguous vertebræ, the ridge applying itself to the intervening cartilage. Now this is the very contrivance which is employed in the famous iron bridge at my door at Bishop-Wearmouth; and for the same purpose of stability; viz. the cheeks of the bars, which pass between the arches, ride across the joints, by which the pieces composing each arch are united. Each cross-bar rests upon two of these pieces at their place of junction; and by that position resists, at least in one direction, any tendency in either piece to slip out of its place. Thus perfectly, by one means or the other, is the danger of slipping laterally, or of being drawn aside out of the *line* of the back provided against: and, to withstand the bones being pulled asunder longitudinally, or in the direction of the line, a strong membrane runs from one end of the chain to the other, sufficient to resist any force which is ever likely to act in the direction of the back, or parallel to it, and consequently to secure the whole combination in their places. The general result is, that not only the motions of the human body necessary for the ordinary offices of life are performed with safety, but that it is an accident hardly ever heard of, that even the gesticulations of a harlequin distort his spine.

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

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

IV. The reciprocal enlargement and contraction of the *chest* to allow for the play of the lungs, depends upon a simple yet beautiful mechanical contrivance, referable to the structure of the bones which inclose

* Der. Phys. Theol. p. 39.

it. The ribs are articulated to the back bone, or rather to its side projections, *obliquely;* that is, in their natural position they bend or slope from the place of articulation downwards. But the basis upon which they rest at this end being fixed, the consequence of the obliquity, or the inclination downwards, is, that, when they come to move, whatever pulls the ribs upwards, necessarily, at the same time, draws them out; and that, whilst the ribs are brought to a right angle with the spine behind, the sternum, or part of the chest to which they are attached in front, is thrust forward. The simple action, therefore, of the elevating muscles does the business; whereas, if the ribs had been articulated with the bodies of the vertebræ at right angles, the cavity of the thorax could never have been further enlarged by a change of their position. If each rib had been a rigid bone, articulated at both ends to fixed bases, the whole chest had been immovable. Keill has observed, that the breast-bone, in an easy inspiration, is thrust out one tenth of an inch; and he calculates that this, added to what is gained to the space within the chest by the flattening or descent of the diaphragm, leaves room for forty-two cubic inches of air to enter at every drawing in of the breath. When there is a necessity for a deeper and more laborious inspiration, the enlargement of the capacity of the chest may be so increased by effort, as that the lungs may be distended with seventy or a hundred such cubic 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; in its form and office unlike any other bone of the body. It is circular; the size of a crown piece; pretty thick; a little convex on both sides, and cov-

* Anat. p. 229.

ered with a ſmooth cartilage. It lies upon the front of the knee; and the powerful tendons, by which the leg is brought forward, paſs through it (or rather it makes a part of their continuation) from their origin in the thigh to their inſertion in the tibia. It protects both the tendon and the joint from any injury which either might ſuffer, by the rubbing of one againſt the other, or by the preſſure of unequal ſurfaces. It alſo gives to the tendons a very conſiderable mechanical advantage by altering the line of their direction, and by advancing it further out from the centre of motion; and this upon the principles of the reſolution of force, upon which principles all machinery is founded. Theſe are its uſes. But what is moſt obſervable in it is, that it appears to be ſupplemental, as it were, to the frame; added, as it ſhould almoſt ſeem, afterward; not quite neceſſary, but very convenient. It is ſeparate from the other bones; that is, it is not connected with any other bones by the common mode of union. It is ſoft, or hardly formed, in infancy; and produced by an oſſification, of the inception or progreſs of which, no account can be given from the ſtructure or exerciſe of the part.

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

I. THE ABOVE are a few examples of bones made remarkable by their configuration: but to almoſt all the bones belong *joints;* and in theſe, ſtill more clearly than in the form or ſhape of the bones themſelves, are ſeen both contrivance and contriving wiſdom. Every joint is a curioſity, and is alſo ſtrictly mechanical. There is the hinge joint, and the mortice and tenon joint; each as manifeſtly ſuch, and as accurately defined, as any which can be produced out of a cabinet-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 have 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 channeled 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 re ceived bones a little below their heads, incloſes the joint on every ſide. This membrane ties, confines, and holds the ends of the bones together; keeping the correſponding parts of the joint, i. e. the relative convexities and concavities, in cloſe application to each other.

For the *ball and ſocket joint*, beſide the membrane already deſcribed, there is in ſome important joints, as an additional ſecurity, a ſhort, ſtrong, yet flexible ligament, inſerted, by one end into the head of the ball, by the other into the bottom of the cup; which ligament keeps the two parts of the joint ſo firmly in their place, that none of the motions which the limb naturally performs, none of the jerks and twiſts to which it is ordinarily liable, nothing leſs indeed than the utmoſt and the moſt unnatural violence, can pull them aſunder. It is hardly indeed imaginable, how great a force is neceſſary, even to ſtretch, ſtill more to break, this ligament; yet ſo flexible is it, as to oppoſe no impediment to the ſuppleneſs of the joint. By its ſituation alſo, it is inacceſſible to injury from ſharp edges. As it cannot be ruptured, ſuch is its ſtrength; ſo it cannot be cut, except by an accident which would ſever the limb. If I had been permitted to frame a proof of contrivance, ſuch as might ſatisfy the moſt diſtruſtful enquirer, I know not whether I could have choſen an example of mechanifm more unequivocal, or more free from objection, than this ligament. Nothing can be more mechanical; nothing, however fubfervient to the fafety, lefs capable of being generated by the action of the joint. I would particularly folicit the reader's attention to this provifion, as it is found in the head of the *thigh bone;* to its ftrength, its ftructure, and its ufe. It is an inftance upon which I lay my hand. One fingle fact, weighed by a mind in earneft, leaves oftentimes the deepeft impreffion. For the purpofe of addreffing different underftandings and different apprehenfions, for the purpofe of fentiment, for the purpofe of exciting admiration of the Creator's works, we diverfity our views, we multiply examples; but, for the purpofe of ftrict argument, one clear inftance is fufficient: and not only fufficient, but capable perhaps of generating a firmer affurance than what can arife from a divided attention.

The *ginglymus*, or hinge joint, does not, it is manifeft, admit of a ligament of the fame kind with that of the ball and focket joint, but it is always fortified by the fpecies of ligament of which it does admit. The ftrong, firm, invefting membrane above defcribed, accompanies it in every part: and, in particular joints, this membrane, which is properly a ligament, is confiderably ftronger on the fides than either before or behind, in order that the convexities may play true in their concavities, and not be fubject to flip fideways, which is the chief danger; for the mufcular tendons generally reftrain 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 fuperadded to the common provifions for the ftability of the joint, two ftrong ligaments which crofs each other; and crofs each other in fuch a manner, as to fecure the joint from being difplaced in any affignable direction.

"I think," says Chefelden, "that the knee cannot be completely diflocated without breaking the *crofs* ligaments."* We can hardly help comparing this with the binding up of a fracture, where the fillet is almoft always ftrapped acrofs, for the fake of giving firmnefs and ftrength to the bandage.

Another no lefs important joint, and that alfo of the ginglymus fort, is the *ankle*; yet, though important, (in order, perhaps, to preferve the fymmetry and lightnefs of the limb) *fmall*, and, on that account, more liable to injury. Now this joint is ftrengthened, i. e. is defended from diflocation, by two remarkable proceffes or prolongations of the bones of the leg, which proceffes 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: fo that, if the joint be in danger of flipping outward, it is curbed by the inner projection, i. e. that of the tibia; if inward, by the outer production, i. e. that of the fibula. Between both, it is locked in its pofition. I know no account that can be given of this ftructure except its utility. Why fhould the tibia terminate at its lower extremity with a double end, and the fibula the fame, but to barricade the joint on both fides by a continuation of part of the thicknefs of the bone over it?

The joint at the *fhoulder*, compared with the joint at the *hip*, though both ball and focket joints, difcover a difference in their form and proportions, well fuited to the different offices which the limbs have to execute. The cup or focket at the fhoulder is much fhallower and flatter than it is at the hip, and is alfo in part formed of cartilage fet round the rim of the cup. The focket, into which the head of the thigh bone is inferted, is deeper, and made of more folid materials. This agrees with the duties affigned to each part.—

* Chef. Anat. 7th ed. p. 45.

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 freer motion and a wider 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 moveable 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 hamstrings, 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 bone, is a *notch* which is joined or covered at the top with a ligament. Through this hole, thus guarded, the blood-vessels steal to their destination in the arm, instead of mounting over the edge of the concavity.‡

III. In all joints, the ends of the bones, which work against each other, are tipped with *gristle*. In the ball and socket joint, the cup is lined, and the ball capped with it. The smooth surface, the elastic and unfriable nature of cartilage, render it of all substances the properest for the place and purpose. I should therefore have pointed this out amongst the foremost of the provisions which have been made in the joints for the facilitating of their action, had it not been alledged, that cartilage in truth is only nascent or imperfect bone; and that the bone in these places is kept soft and imperfect, in consequence of a more

* Ches. An, p. 255, ed. 7th. † Ib. p. 35. ‡ Ib. 30.

complete and rigid offification being prevented from taking place by the continual motion and rubbing of the furfaces. Which being fo, what we reprefent as a defigned advantage, is an unavoidable effect. I am far from being convinced that this is a true account of the fact; or that, if it were fo, it anfwers the argument. To me, the furmounting of the ends of the bones with griftle, looks more like a plating with a different metal, than like the fame metal kept in a different ftate by the action to which it is expofed. At all events we have a great particular benefit, tho' arifing from a general conftitution: but this laft not being quite what my argument requires, left I fhould feem by applying the inftance, to overrate its value, I have thought it fair to ftate the queftion which attends it.

IV. In fome joints, very particularly in the knees, there are loofe cartilages or griftles between the bones, and within the joint, fo that the ends of the bones, inftead of working upon one another, work upon the intermediate cartilages. Chefelden has obferved,* That the contrivance of a loofe ring is practifed by mechanics, where the friction of the joints of any of their machines is great; as between the parts of crook hinges of large gates, or under the head of the male fcrew of large vices. The cartilages of which we fpeak have very much of the form of thefe rings. The comparifon moreover fhews the reafon why we find them in the knees rather than in other joints. It is an expedient, we have feen, which a mechanic reforts to, only when fome ftrong and heavy work is to be done. So here the thigh bone has to achieve its motion at the knee, with the whole weight of the body preffing upon it, and often, as in rifing from our feat, with the whole weight of the body to lift. It fhould feem alfo from Chefelden's account, that

* Ib. p. 13.

the flipping and fliding of the loofe cartilages, though it be probably a fmall and obfcure change, humored the motion of the end of the thigh bone, under the particular configuration which was neceffary to be given to it for the commodious action of the tendons; and which configuration requires what he calls a variable focket, that is, a concavity, the lines of which affume a different curvature in different inclinations of the bones.

V. We have now done with the configuration; but there is alfo in the joints, and that common to them all, another exquifite provifion, manifeftly adapted to their ufe, and concerning which there can, I think, be no difpute, namely, the regular fupply of a *mucilage*, more emollient and flippery than oil itfelf, which is conftantly foftening and lubricating the parts that rub upon each other, and thereby diminifhing the effect of attrition in the higheft poffible degree. For the continual fecretion 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 balfamic contents, hang loofe like fringes within the cavity of the joints. A late improvement in what are called friction wheels, which confifts of a mechanifm fo ordered, as to be regularly dropping oil into a box, which inclofes the axis, the nave, and certain balls upon which the nave revolves, may be faid, in fome fort, to reprefent the contrivance in the animal joint; with this fuperiority, however, on the part of the joint, viz. that here, the oil is not only dropped, but *made*.

In confidering the joints, there is nothing, perhaps, which ought to move our gratitude more than the reflection, *how well they wear*. A limb fhall fwing upon its hinge, or play in its focket, many hundred times in an hour, for fixty years together, without dimination of its agility: which is a long time for any thing to laſt; for any thing 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 cartilaginous ſurfaces, ſecondly, by the healing lubrication of the mucilage; and, in part, to that aſtoniſhing property 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.

Moveable joints, I think, compoſe the curioſity of bones; but their union, even where no motion is intended 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 buſineſs 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 at 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 the 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 taylor'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 the articulation: the 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 brachiæus *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 fore-arm 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 brachiæus *externus*, and the anconæus, placed on the hinder part of the arm, by their contractile twitch fetch back the fore-arm 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 moveable 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 ſawers 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 held 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 there 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 inconveniency; but it ſhews 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 ligament 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

* Keill's Anat. p. 295, ed. 3d.

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 globe, where it lies safe, and where it incumbers 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 hour at eaſe! How many more to be vigorous and active! Yet vigor and activity are, in a vaſt plurality of inſtances, preſerved in human bodies, notwithſtanding that they depend upon ſo great a number of inſtruments of motion, and notwithſtanding that the defect or diſorder ſometimes of a very ſmall inſtrument, of a ſingle pair, for inſtance, out of the four hundred and forty-ſix muſcles which are employed, may be attended with grievous inconveniency. There is piety and good ſenſe in the following obſervation, taken out of the *Religious Philoſopher*. "With much compaſſion," ſays this writer, "as well as aſtoniſhment at the goodneſs of our loving Creator, have I conſidered the ſad ſtate of a certain gentleman, who, as to the reſt, was in pretty good health, but only wanted the uſe of theſe *two little muſcles* that ſerve to lift up the eyelids, and ſo had almoſt loſt the uſe of his ſight, being forced, as long as this defect laſted, to ſhove up his eyelids every moment with his own hands!" In general we may remark how little thoſe, who enjoy the perfect uſe of their organs, know the comprehenſiveneſs of the bleſſing, the variety of their obligation. They perceive a reſult, but they think little of the multitude of concurrences and rectitudes which go to form it.

BESIDE theſe obſervations, which belong to the muſcular organ as ſuch, we may notice ſome advantages of ſtructure which are more conſpicuous in muſcles of a certain claſs or deſcription than in others. Thus,

I. The variety, quickneſs, and preciſion, of which muſcular motion is capable, are ſeen, I think, in no part ſo remarkably as in the *tongue*. It is worth any man's while to watch the agility of his tongue; the wonderful promptitude with which it executes changes of poſition, and the perfect exactneſs. Each ſyllable of articulated ſound requires for its utterance a ſpecific action of the tongue, and of the parts adjacent to it. The dpiſoſition and configuration of the mouth, appertaining to every letter and word, is not only peculiar, but, if nicely and accurately attended to, perceptible to the ſight; inſomuch that curious perſons have availed themſelves of this circumſtance to teach the deaf to ſpeak, and to underſtand what is ſaid by others. In the ſame perſon, and after his habit of ſpeaking is formed, one, and only one poſition of the parts, will produce a given articulate ſound correctly. How inſtantaneouſly are theſe poſitions aſſumed and diſmiſſed; how numerous are the permutations, how various, yet how infallible? Arbitrary and antic variety is not the thing we admire; but variety obeying a rule, conducing to an effect, and commenſurate with exigencies infinitely diverſified. I believe alſo that the anatomy of the tongue correſponds with theſe obſervations 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 what might ſeem to be the entanglement of its fibres, in any wiſe impede its motion, or render the determination or ſucceſs of its efforts uncertain.

I here intreat 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 mean time, 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 to 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 ſpringing up in different parts of the cavity for the moiſtening of the food, whilſt 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 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 upward by muſcular ſtrength, inſtead of deſcending of its own accord.

In the mean time, and within the ſame cavity, is going on other 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 pnuematic 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 inconveniences 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 circumftance which always appeared to me worthy of notice. The nofe would have been neceffary, although it had not been the organ of fmelling. The making it the feat of a fenfe, was fuperadding a new ufe to a part already wanted: was taking a wife advantage of an antecedent and a conftitutional neceffity.

But to return to that, which is the proper fubject of the prefent fection, the celerity and precifion of mufcular motion. Thefe qualities may be particularly obferved in the execution of many fpecies of inftrumental *mufic*, in which the changes produced by the hand of the mufician are exceedingly rapid; are exactly meafured, even when moft minute; and difplay, on the part of the mufcles, an obedience of action, alike wonderful for its quicknefs and its correctnefs.

Or let a perfon only obferve his own hand whilft he is *writing;* the number of mufcles, which are brought to bear upon the pen; how the joint and adjufted operation of feveral tendons is concerned in every ftroke, yet that five hundred fuch ftrokes are drawn in a minute. Not a letter can be turned without more than one or two or three tendinous contractions, definite, both as to the choice of the tendon, and as to the fpace through which the contraction moves; yet how currently does the work proceed? and, when we look at it, how faithful have the mufcles been to their duty, how true to the order which endeavour or habit hath inculcated? For let it be remembered, that, whilft a man's hand writing is the fame, an exactitude of order is preferved, whether he write well or ill. Thefe two inftances of mufic and writing, fhew not only the quicknefs and precifion of mufcular action, but the docility.

II. Regarding the particular configuration of muscles, *sphincter* or circular muscles appear to me admirable pieces of mechanism. It is the muscular power most happily applied; the same quality of the muscular substance, but under a new modification. The circular disposition of the fibres is strictly mechanical; but, though the most mechanical, is not the only thing in sphincters which deserves our notice. The regulated 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 dependance 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 hath 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 obferved,* that the moft important and the moft delicate actions are performed in the body by the fmalleft mufcles: and he mentions, as his examples, the mufcles which have been difcovered in the iris of the eye and the drum of the ear. The tenuity of thefe mufcles is aftonifhing. They are microfcopic hairs; muft be magnified to be vifible; yet are they real effective mufcles; and not only fuch, but the grandeft and moft precious of our faculties, fight and hearing, depend upon their health and action.

V. The mufcles act in the limbs with what is called a mechanical difadvantage. The mufcle at the fhoulder, by which the arm is raifed, is fixed nearly in the fame manner, as the load is fixed upon a fteelyard, within a few decimals, we will fay, of an inch, from the centre upon which the fteelyard turns. In this fituation, we find that a very heavy draught is no more than fufficient to countervail the force of a fmall lead plummet, placed upon the long arm of the fteelyard, at the diftance of perhaps fifteen or twenty inches from the centre, and on the other fide of it. And this is the difadvantage which is meant. And an abfolute difadvantage, no doubt, it would be, if the object were to fpare the force of mufcular contraction. But obferve how conducive is this conftitution to animal conveniency. Mechanifm has always in view one or other of thefe two purpofes; either to move a great weight flowly, and through a fmall fpace; or to move a light weight rapidly, through a confiderable fweep. For the former of thefe purpofes, a different fpecies of lever, and a different collocation of the mufcles, might be better than the prefent: but for the fecond, the prefent ftructure is the true one. Now fo it happens, that the fecond, and not the firft, is that

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

which the occaſions of animal 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, upon ſome extraordinary occaſions, he may deſire to poſſeſs; but the other is what he wants and uſes every hour and 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 in ſuch a manner, as to be, I think, ſufficiently comprehended for our preſent purpoſe. The problem is to pull the lower jaw *down*. The obvious method ſhould ſeem to be, to place a ſtraight muſcle, viz. to fix a ſtring from the chin to the breaſt, the contraction of which would open the mouth, and produce the motion required at once. But it is evident that the form and liberty of the neck forbid a muſcle being laid in ſuch a poſition; and that, conſiſtently with the preſervation of this form, the motion, which we want, muſt be effectuated, by ſome muſcular mechaniſm diſpoſed further back in the jaw. The mechaniſm adopted is as follows: A certain muſcle, called the *digaſtric*, riſes on the ſide of the face, conſiderably *above* the inſertion of the lower jaw; and comes down, being converted in its progreſs into a round tendon. Now it is evident, that the tendon, whilſt it purſues a direction *deſcending* towards the jaw, muſt, by its contraction, pull the jaw up, inſtead of down. What then was to be done? This, we find, is done. The deſcending tendon, when it is got low enough, is paſſed through a loop, or ring, or pulley, in the os hyoides, and then made to aſcend; and, having thus changed its line of direction, is inſerted into the inner part of the chin: by which device, viz. the turn at the loop, the action of the muſcle (which in all muſcles is contraction) that before would have pulled the jaw up, now as neceſſarily draws it down. "The mouth," ſaith Heiſter, "is opened by means of this trochlea in a moſt wonderful 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 at the ancle. 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 preventative 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, 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 con-

* Chef. Anat. p. 93, 119.

ſtrains the tendons; the tendons react 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 endeavouring, 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 an uſe to every one of the number. This cannot be all imagination.

Biſhop Wilkins 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, 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 was well said by an able anatomist,* and said in reference to the very part 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 mechanices artificia, creberrime in illis obvia, verbis nonnisi obscure 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 subtile and intricate; nay, it is possible that in their structure they 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

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

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 received into it by one aperture. What enters at the mouth, finds its way to the finger's ends. A more difficult mechanical problem could hardly, I think, be proposed, than to discover a method 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, the disposition of the blood-vessels, i. e. the laying of the pipes; and, secondly, the construction of the engine at the centre, viz. the heart, for driving the blood through them.

I. The disposition of the blood-vessels, as far as regards the supply of the body, is like that of the water pipes in a city, viz. large and main trunks branching off by smaller pipes (and these again by still narrower tubes) 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 a reversed system of vessels is prepared, which, uniting at their extremities with the extremities of the first system, collects the divided and subdivided streamlets, first by 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 from whence its motion proceeded. All which is evident mechanism.

The body, therefore, contains two systems of blood-vessels, arteries and veins. Between the constitution of the systems there are also two differences, suited to the functions which the systems have to execute. The blood, in going out, passing always from wider into narrower tubes; and, in coming back, from narrower into wider; it is evident, that the impulse and pressure upon the sides of the blood-vessels, will be much greater in one case than the other. Accordingly, the arteries which carry out the blood, are formed with much tougher and stronger coats, than the veins which bring it back. That is one difference: the other is still more artificial, or, if I may so speak, indicates, still more clearly, the care and anxiety of the artificer. Forasmuch as in the arteries, by reason of the greater force with which the blood is urged along them, a wound or rupture would be more dangerous, than in the veins, these vessels are defended from injury, not only by their texture, but by their situation; and by every advantage of situation which can be given to them. They are buried in sinuses, or they creep along grooves, made for them, in the bones; for instance, the under edge of the ribs is sloped and furrowed solely for the passage of these vessels. Sometimes they proceed in channels, protected by stout parapets on each side; which last description is remarkable in the bones of the fingers, these being hollowed out, on the under side, like a scoop, and with such a concavity that the finger may be cut across to the bone without hurting the artery which runs along it. At other times, the arteries pass in canals wrought in the substance, and in the very middle of the substance, of the bone: this takes place in the 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 the 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 carried 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 the nervous fluid, or whatever else be the cause of its motion, it is something, which is capable of producing, in a living muscular fibre, reciprocal contraction and relaxation. This is the power we have to work with: and the enquiry is, how this power is applied in the instance before us. There is provided in the central part of the body a hollow muscle, invested with spiral fibres, running in both directions, the layers intersecting one another; in some animals, however, appearing to be semicircular rather than spiral. By the contraction of these fibres, the sides of the mufcular cavities are neceffarily fqueezed together, fo as to force out from them any fluid which they may at that time contain: by the relaxation of the fame fibres, the cavities are in their turn dilated; and, of courfe, prepared to admit every fluid which may be poured into them. Into thefe cavities are inferted the great trunks, both of the arteries which carry out the blood, and of the veins which bring it back. This is a general account of the apparatus: and the fimpleft idea of its action is, that, by each contraction, a portion of blood is forced as by a fyringe into the arteries; and, at each dilatation, an equal portion is received from the veins. This produces, at each pulfe, a motion and change in the mafs of blood, to the amount of what the cavity contains, which in a full grown human heart, I underftand, is about an ounce, or two table-fpoons full. How quickly thefe changes fucceed one another, and by this fucceffion how fufficient they are to fupport a ftream or circulation throughout the fyftem, may be underftood by the following computation, abridged from Keill's Anatomy, p. 117. ed. 3. "Each ventricle will at leaft contain one ounce of blood. The heart contracts four thoufand times in one hour; from which it follows, that there paffes through the heart, every hour, four thoufand ounces, or three hundred and fifty pounds of blood. Now the whole mafs of blood is faid to be about twenty-five pounds, fo that a quantity of blood equal to the whole mafs of blood paffes through the heart fourteen times in one hour; which is about once every four minutes." Confider what an affair this is, when we come to very large animals. The aorta 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 paffage through that pipe, is inferior, in impetus and velocity, to the blood gufhing from the whale's heart. Hear Dr.

Hunter's account of the diffection of a whale. "The aorta meafured a foot diameter. Ten or fifteen gallons of blood is thrown out of the heart at a ftroke with an immenfe velocity, through a tube of a foot diameter. The whole idea fills the mind with wonder."*

The account which we have here ftated, of the injection of blood into the arteries by the contraction, and of the correfponding reception of it from the veins by the dilatation, of the cavities of the heart, and of the circulation being thereby maintained thro' the blood veffels of the body, is true, but imperfect. The heart performs this office, but it is in conjunction with another of equal curiofity and importance. It was neceffary that the blood fhould be fucceffively brought into contact, or contiguity, or proximity with the *air*. I do not know that the chymical reafon, upon which this neceffity is founded, has been yet fufficiently explored. It feems to be made appear, that the atmofphere which we breathe is a mixture of two kinds of air; one pure and vital, the other, for the purpofes of life, effete, foul, and noxious: that when we have drawn in our breath, the blood in the lungs imbibes from the air, thus brought into contiguity with it, a portion of its pure ingredient; and, at the fame time, gives out the effete or corrupt air which it contained, and which is carried away, along with the halitus, every time we expire. At leaft; by comparing the air which is breathed from the lungs, with the air before it enters the lungs, it is found to have loft fome of its pure part, and to have brought away with it an addition of its impure part. Whether thefe experiments fatisfy the queftion, as to the need which the blood ftands in, of being vifited by continual acceffes of air, is not for us to enquire into; nor mate-

* Dr. Hunter's account of the diffection of a whale. Phil. Tranf.

rial to our argument: it is sufficient to know, that, in the constitution of most animals such a necessity exists, and that the air, by some means or other, *must* be introduced into a near communication with the blood. The lungs of animals are constructed for this purpose. They consist of blood-vessels and air-vessels lying close to each other; and wherever there is a branch of the trachea or windpipe, there is a branch accompanying it of the vein and artery, and the air-vessel is always in the middle between the blood-vessels.* The internal surface of the 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 veins of the body, and *before* that it 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 from 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

* Keill's Anat. p. 121.

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 its circulation through the lungs. So that there are two receiving cavities, and two forcing cavities. The ſtructure of the heart has reference to the lungs, for without the lungs one of each would have been ſufficient. The tranſlation of the blood in the heart itſelf is after this manner. The receiving cavities reſpectively communicate with the forcing cavities, and, by their contraction, unload the received blood into them. The forcing cavities, when it is their turn to contract, compel the ſame blood into the mouths of the arteries.

The account here given will not convey to a reader ignorant of anatomy, any thing like an accurate notion of the form, action, or uſe of the parts, (nor can any ſhort and popular account do this) but it is abundantly ſufficient to teſtify contrivance; and, although imperfect, being true as far as it goes, may be relied upon for the only purpoſe for which we offer it, the purpoſe of this concluſion.

"The wiſdom of the Creator," ſaith Hamburgher, "is in nothing ſeen more glorioufly than in the heart." And how well doth it execute its office! An anatomiſt, who underſtood the ſtructure of the heart, might ſay beforehand that it would play; but he would expect, I think, from the complexity of its mechaniſm, and the delicacy of many of its parts, that it ſhould always be liable to derangement, or that it would ſoon work itſelf out Yet ſhall this wonderful machine go, night and day, for eighty years together, at the rate of a hundred thouſand ſtrokes every twenty-four hours, having, at every ſtroke, a great reſiſtance to overcome; and ſhall continue this action for this length of time, without diſorder, and without wearineſs.

But further; from the account, which has been given of the mechanism of the heart, it is evident that it must require the interposition of *valves;* that the success indeed of its action must depend upon these, for when any one of its cavities contracts, the necessary tendency of the force will be to drive the inclosed blood, not only into the mouth of the artery where it ought to go, but also back again into the mouth of the vein from which it flowed. In like manner, when by the relaxation of the fibres the same cavity is dilated, the blood would not only run into it from the vein, which was the course intended, but back from the artery, through which it ought to be moving forward. The way of preventing a reflux of the fluid, in both these cases, is to fix valves; which, like flood-gates, may open a way to the stream in one direction, and shut up the passage against it in another. The heart, constituted as it is, can no more work without valves than a pump can. When the piston descends in a pump, if it were not for the stoppage by the valve beneath, the motion would only thrust down the water which it had before drawn up. A similar consequence would frustrate the action of the heart. Valves therefore properly disposed, i. e. properly with respect to the course of the blood which it is necessary to promote, are essential to the contrivance. *And valves so disposed are, accordingly, provided.* A valve is placed in the communication between each auricle and its ventricle, lest, when the ventricle contracts, part of the blood should get back again 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 whilſt 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 fulfills 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 baſes 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 them from proceeding or ſeparating further;) which cone, entirely occupying the paſſage, prevents the return of the blood into the auricle. A ſhorter account of the matter may be this: So long as the blood proceeds in its proper courſe, the membranes which compoſe the valve are preſſed cloſe to the ſide of the veſſel, and occaſion no impediment to the circulation; when the blood would regurgitate, they are raiſed from the ſide of the veſſel, and meeting in the middle of its cavity, ſhut up the channel. Can any one doubt of contrivance here; or is it poſſible to ſhut our eyes againſt the proof of it?

This valve alſo, is not more curious in its ſtructure, than it is important in its office. Under the play of the valve, even upon the proportioned length of the ſtrings or fibres which check the aſcent of the membranes, depends, as it ſhould ſeem, nothing leſs than the life itſelf of the animal. We may here likewiſe repeat, what we before obſerved concerning ſome of the ligaments of the body, that they could not be formed by any action of the parts themſelves. There are caſes, in which, although good uſes appear to ariſe from the ſhape or configuration of a part, yet that ſhape and configuration itſelf may ſeem to be produced by the action of the part, or by the action or preſſure of adjoining parts. Thus the bend, and the internal ſmooth concavity of the ribs, may be attributed to the equal preſſure of the ſoft bowels; the particular ſhape of ſome bones and joints, to the traction of the annexed muſcles, or to the poſition of contiguous muſcles. But valves could not 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 attention, 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 incloſing of it in a ſac, anſwering no other purpoſe but that incloſure, ſhew the care that has been taken of its preſervation?

ONE USE of the circulation of the blood (probably amongſt other uſes) is to diſtribute nouriſhment to the different parts of the body. How minute and multiplied the ramifications of the blood-veſſels, for that purpoſe, are; and how thickly ſpread, over at leaſt the ſuperficies of the body, is proved by the ſingle obſervation, that we cannot prick the point of a pin into the fleſh, without drawing blood, i. e. without finding a blood-veſſel. Nor, internally, is their diffuſion leſs univerſal. Blood-veſſels run along the ſurface of membranes, pervade the ſubſtance of muſcles, penetrate the bones. Even into every tooth, we trace, through a ſmall hole in the root, an artery to feed the bone, as well as a vein to bring back the ſpare blood from it; both which, with the addition of an accompanying nerve, form a thread only a little thicker than a horſe-hair.

WHEREFORE, when the nouriſhment taken in at the mouth, has once reached, and mixed itſelf with, the blood, every part of the body is in the way of being ſupplied with it. And this introduces another grand topic, namely, the manner in which the aliment gets into the *blood*; which is a ſubject diſtinct from the preceding, and brings us to the conſideration of another entire ſyſtem of veſſels.

I. For this neceſſary part of the animal œconomy, an apparatus is provided, in a great meaſure, capable of being, what anatomiſts call, demonſtrated, that is, ſhewn in the dead body; and a line or courſe of conveyance, which we can purſue by our examinations.

Firſt, the food deſcends by wide paſſages into the inteſtines, undergoing two great preparations on its way, one, in the mouth by maſtication and moiſture, (can it be doubted with what deſign the teeth were placed in the road to the ſtomach, or that there was choice in fixing them in this ſituation?) the other, by digeſtion in the ſtomach itſelf. Of this laſt ſurpriſing diſſolution I ſay nothing; becauſe it is chymiſtry, and I am endeavoring to diſplay mechaniſm. The figure and poſition of the ſtomach (I ſpeak all along with a reference to the human organ) are calculated for detaining the food long enough for the action of its digeſtive juice. It has the ſhape of the pouch of a bagpipe; lies acroſs the body; and the pylorus, or paſſage by which the food leaves it, is ſomewhat higher in the body, than the cardia or orifice by which it enters; ſo that it is by the contraction of the muſcular coat of the ſtomach, that the contents, after having undergone the application of the gaſtric menſtruum, are gradually preſſed out. In dogs and cats, this action of the coats of the ſtomach has been diſplayed to the eye. It is a ſlow and gentle undulation, propagated from one orifice 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 concerning the bile or the pancreatic juice, further than to obſerve 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 mixed with the aliment, as soon almost as it passes the stomach: adding also as a remark, how grievously this same bile offends the stomach itself, yet cherishes the vessel that lies next to it.

Secondly, we have now the aliment in the intestines, converted into pulp, and, though lately consisting of perhaps ten different viands, reduced to nearly an uniform substance, and to a state fitted for yielding its essence, which is called chyle, but which is milk, or more nearly resembling milk than any other liquor with which it can be compared. For the straining off of this fluid from the digested aliment in the course of its long progress through the body, myriads of capillary tubes, i. e. pipes as small as hairs, open their orifices into the cavity of every part of the intestines. These tubes, which are so fine and slender as not to be visible, unless when distended with chyle, soon unite into larger branches. The pipes, formed by this union, terminate in glands, from which other pipes of a still larger diameter arising, carry the chyle, from all parts, into a common reservoir or *receptacle*. This receptacle is a bag, large enough to hold about two table spoonfuls; and from this vessel a duct or main pipe proceeds, climbing up the back part of the chest, and then creeping along the gullet till it reach the neck. Here it meets the river. Here it discharges itself into a large vein, which soon conveys the chyle, now flowing along with the old blood, to the heart. This whole route can be exhibited to the eye. Nothing is left to be supplied by imagination or conjecture. Now, beside the subserviency of this whole structure to a manifest and necessary purpose, we may remark two or three separate particulars in it, which shew, not only the contrivance, but the perfection of it. We may remark, first, the length of the intestines, which, in the human subject, is six times that of the body. Simply for a passage, these voluminous bowels, this prolixity of gut, seems in no wise necessary; but, in order to allow time and space for the successive extraction of the chyle from the digested aliment, namely, that the chyle, which escapes the lacteals of one part of the guts, may be taken up by those of some other part, the length of the canal is of evident use and conduciveness. Secondly, we must also remark their peristaltic motion; which is made up of contractions, following one another like waves upon the surface of a fluid, and not unlike what we observe in the body of an earthworm crawling along the ground; and which is effected by the joint action of longitudinal and of spiral, or rather perhaps of a great number of separate semicircular fibres. This curious action pushes forward the grosser part of the aliment, at the same time that the more subtile parts, which we call chyle, are, by a series of gentle compressions, squeezed into the narrow orifices of the lacteal veins. Thirdly, it was necessary that these tubes, which we denominate lacteals, or their mouths at least, should be made as narrow as possible, in order to deny admission into the blood to any particle which is of size enough to make a lodgement afterwards in the small arteries, and thereby to obstruct the circulation: and it was also necessary that this extreme tenuity should 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 diſcernable 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. Theſe 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 inteſtines and the left great vein of the *neck?* Who could have ſuſpected that this communication ſhould be the medium through which all nouriſhment is derived to the body? Or this the place, where, by a ſide inlet, the important junction is formed between the blood and the material which feeds it?

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

Of the gaſtric juice, the immediate agent, by which that change which food undergoes in our ſtomachs is effected, we ſhall take our account, from the numerous, careful, and varied experiments, of the Abbé Spallanzani.

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

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

3. Digeſtion is not *putrefaction;* for it reſiſts putrefaction moſt pertinaciouſly; nay, not only checks its further progreſs, but reſtores putrid ſubſtances.

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

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

In a word, animal digeſtion carries about it the marks of being a power and a proceſs completely *ſui generis;* diſtinct from every other; at leaſt from every chymical proceſs with which we are acquainted. And the moſt wonderful thing about it is its appropriation; its ſubſerviency to the particular œconomy of each animal. The gaſtric juice of an owl, falcon, or kite, will not touch grain; no, not even to finiſh the macerated and half digeſted pulſe, which is left in the crops of the ſparrows that the bird devours. In poultry, the trituration of the gizzard, and the gaſtric juice, conſpire in the work of digeſtion. The gaſtric juice will not diſſolve the grain whilſt it is whole. Grains of barley incloſed in tubes or ſpherules are not affected by it. But if the same grain be by any means broken or ground, the gastric juice immediately lays hold of it. Here then is wanted, and here we find, a combination of mechanism and chymistry. For the preparatory grinding, the gizzard lends its mill. And, as all mill work should be strong, its structure is so, beyond that of any other muscle belonging to the animal. The internal coat also, or lining of the gizzard, is, for the same purpose, hard and cartilaginous. But, forasmuch as this is not the sort of animal substance suited for the reception of glands, or for secretion, the gastric juice, in this family, is not supplied, as in membranous 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 as common water would produce, in a degree of heat somewhat exceeding the medium temperature of the atmosphere. But, provided that the plant has been reduced to pieces by chewing, the gastric juice then proceeds with it, first by softening its substance; next by destroying its natural consistency; and, lastly, by dissolving it so completely, as not even to spare the toughest and most stringy parts, such as the nerves of the leaves.

So far our accurate and indefatigable Abbé. Dr. Stevens of Edinburgh, in 1777, found by experiments tried with perforated balls, that the gastric juice of the sheep and the ox speedily dissolved vegetables, but made no impression upon beef, mutton, and other animal bodies. Dr. Hunter discovered a property of this fluid, of a most curious kind; viz. that, in the stomachs of animals which feed upon flesh, irresistibly as this fluid acts upon animal substances, it is only upon the *dead* ſubſtance, that it operates at all. The *living* fibre ſuffers no injury from lying in contact with it. Worms and inſects are found alive in the ſtomachs of ſuch animals. The coats of the human ſtomach, in a healthy ſtate, are inſenſible to its preſence: yet, in caſes of ſudden death, (wherein the gaſtric juice, not having been weakened by diſeaſe, retains its activity,) it has been known to eat a hole through the bowel which contains it.* How nice is this diſcrimination of action, yet how neceſſary?

But to return to our hydraulics.

III. The gall bladder is a very remarkable contrivance. It is the reſervoir of a canal. It does not form the channel 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 occaſions 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 diſtenſion 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

* Phil Tranſac. vol. lxii. p. 447. † Keill's Anat. p. 64.
‡ Anat. p. 164.

received into the inteſtine, at a right time, and in a due proportion.

There may be other purpoſes anſwered by this contrivance; and it is probable that there are. The contents of the gall bladder are not exactly of the ſame kind as what paſſes 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 fingers breadth *between* the coats, before it open 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 into 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.

IV. Amongſt the *veſſels* of the human body, the pipe which conveys the ſaliva from the place where

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

it is made, to the place where it is wanted, deserves to be reckoned amongst the most intelligible pieces of mechanism with which we are acquainted. The saliva, we all know, is used in the mouth; but much of it is manufactured on the outside of the cheek, by the parotid gland, which lies between the ear and the angle of the lower jaw. In order to carry the secreted juice to its destination, there is laid from the gland on the outside, a pipe, about the thickness of a wheat straw, and about three fingers breadth in length; which, after riding over the masseter muscle, bores for itself a hole through the very middle of the cheek; enters by that hole, which is a complete perforation of the buccinator muscle, into the mouth; and there discharges its fluid very copiously.

V. Another exquisite structure, differing indeed from the four preceding instances, in that it does not relate to the conveyance of fluids, but still belonging, like these, to the class of pipes or conduits of the body, is seen in the *larynx*. We all know, that there go down the throat two pipes, one leading to the stomach, the other to the lungs; the one being the passage for the food, the other for the breath and voice: we know also that both these passages open into the bottom of the mouth; the gullet, necessarily, for the conveyance of food; and the windpipe, for speech and the modulation of sound, not much less so: therefore the difficulty was, the passages being so contiguous, to prevent the food, 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. 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 fulfills 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 a crumb of 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 distension by the fluid they inclose, 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 let 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,) beſide 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 windpipe, 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 are requiſite for the performing of it; how many things which we underſtand, to ſay nothing of many more, probably, which we do not; viz. firſt, a long, hard, ſtrong cylinder, in order to give to the arm its firmneſs and tenſion; but which, being rigid, and, in its ſubſtance, inflexible, can only turn upon joints: ſecondly, therefore, joints for this purpoſe, one at the ſhoulder to raiſe the arm, another at the elbow to bend it; theſe joints continually fed with a ſoft mucilage to make the parts ſlip eaſily upon one another, and held together by ſtrong braces to keep them in their poſition: then, thirdly, ſtrings and wires, i. e. muſcles and tendons, artificially inſerted for the purpoſe of drawing the bones in the directions in which the joints allow them to move. Hitherto we ſeem to underſtand the mechaniſm pretty well; and underſtanding this, we poſſeſs enough for our concluſion: nevertheleſs we have hitherto only a machine ſtanding ſtill; a dead organization; an apparatus. To put the ſyſtem in a ſtate of activity (to ſet it at work) a further proviſion is neceſſary, viz. a communication with the brain by means of nerves. We know the exiſtence of this communication, becauſe we can ſee the communicating threads, and can trace them to the brain: its neceſſity we alſo know, becauſe, if the thread be cut, if the communication be intercepted, the muſcle becomes paralytic: but beyond this we know little; the organization being too minute and ſubtile for our inſpection.

To what has been enumerated, as officiating in the ſingle act of a man's raiſing his hand to his head, muſt be added likewife, all that is neceffary, and all that contributes to the growth, nourifhment, and fuftentation of the limb, the repair of its wafte, the prefervation of its health: fuch as the circulation of the blood through every part of it; its lymphatics, exhalants, abforbents; its excretions and integuments. All thefe fhare in the refult; join in the effect: and how all thefe, or any of them, come together without a defigning, difpofing intelligence, it is impoffible to conceive.

CHAPTER XI.

OF THE ANIMAL STRUCTURE REGARDED AS A MASS.

CONTEMPLATING an animal body in its collective capacity, we cannot forget to notice, what a number of inftruments are brought together, and often within how fmall a compafs. In a canary bird, for inftance, and in the ounce of matter which compofes its body (but which feems to be all employed,) we have inftruments for eating, for digefting, for nourifhment, for breathing, for generation, for running, for flying, for feeing, for hearing, for fmelling; each appropriate; each entirely different from all the reft.

The human, or indeed the annimal frame, confidered as a mafs or affemblage, exhibits in its compofition three properties, which have long ftruck my mind, as indubitable evidences, not only of defign, but of a great deal of attention and accuracy in profecuting the defign.

I. The firft is, the exact correfpondency of the two fides of the fame animal: the right hand anfwering to the left, leg to leg, eye to eye, one fide of the countenance to the other; and with a precifion, to 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 œconomy, 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 ſubſerviences to ſpecial occaſions and utilities.

I. The *covering* of different animals (though, whether I am correct in classing this under their anatomy, I don't 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, armour as well as clothing; intended for protection, as well as 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 animal of all climates, and of all seasons. He can adapt the warmth or lightness of his covering to the temperature of his habitation. Had he been born with a fleece upon his back, although he might have been comforted by its warmth in high latitudes, it would have oppressed him by its weight and heat, as the species spread towards the equator.

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

The *covering of birds* cannot eſcape the moſt vulgar obſervation. Its lightneſs, its ſmoothneſs, its warmth; the diſpoſition of the feathers all inclined backward, the down about their ſtem, the overlapping of their tips, their different configuration in different parts, not to mention the variety of their colours, conſtitute a veſtment for the body, ſo beautiful, and ſo appropriate to the life which the animal is to lead, as that, I think, we ſhould have had no conception of any thing equally perfect, if we had never ſeen it, or can now imagine any thing more ſo. Let us ſuppoſe (what is poſſible only in ſuppoſition) a perſon who had never ſeen a bird, to be preſented with a plucked pheaſant, and bid to ſet his wits to work, how to contrive for it a covering which ſhall unite the qualities of warmth, levity, and leaſt reſiſtance to the air, and the higheſt degree of each; giving it alſo as much of beauty and ornament as he could afford. He is the perſon to behold the work of the Deity, in this part of his creation, with the ſentiments which are due to it.

The commendation, which the general aſpect of the feathered world ſeldom fails of exciting, will be increaſed by further examination. It is one of thoſe caſes in which the philoſopher has more to admire, than the common obſerver. Every *feather* is a mechanical wonder. If we look at the quill, we find properties not eaſily brought together, ſtrength and lightneſs. I know few things more remarkable, than the ſtrength and lightneſs of the very pen, with which I am writing. If we caſt our eye to the upper part of the ſtem, we ſee a material, made for the purpoſe, uſed in no other claſs of animals, and in no other part of birds; tough, light, pliant, elaſtic. The pith, alſo, which feeds the feather, 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 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 ſhews 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. Whoever 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 connexion, 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 finger 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 an infinite 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 downward: 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 lamina 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 honours 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.

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 colour 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 colour: 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 was divided into a number of wrens, ſuppoſing the ſhape of the turkey and the wren to be ſimi-

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

lar, the furface of all the wrens would exceed the furface 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 neceffary therefore that fmall birds fhould be warmer clad than large ones; and this feems to be the expedient, by which that exigency is provided for.

II. In comparing different animals, I know no part of their ftructure which exhibits greater variety, or, in that variety, a nicer accommodation to their refpective conveniency, than that which is feen in the different formations of their *mouths*. Whether the purpofe be the reception of aliment merely, or the catching of prey, the picking up of feeds, the cropping of herbage, the extraction of juices, the fuction of liquids, the breaking and grinding of food, the tafte of that food, together with the refpiration of air, and in conjunction with the utterance of found ; thefe various offices are affigned to this one part, and, in different fpecies, provided for, as they are wanted, by its different conftitution. In the human fpecies, forafmuch as there are hands to convey the food to the mouth, the mouth is flat, and by reafon of its flatnefs 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 *fnatch and feize* the objects of their purfuit. The full lips, the rough tongue, the corrugated cartilaginous palate, the broad cutting teeth, of the ox, the deer, the horfe and the fheep, qualify this tribe for *browfing* upon their pafture ; either gathering large mouthfuls at once, where the grafs is long, which is the cafe with the ox in particular ; or biting clofe, where it is fhort, which the horfe and the fheep are able to do, in a degree that one could hardly expect. The retired under jaw of a fwine *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 hard ſubſtance (of the ſame nature with that which compoſes the nails, claws, and hoofs of quadrupeds) cut out into proper ſhapes, and mechanically ſuited to the actions which are wanted. The ſharp edge and tempered point of the *ſparrow's* bill, picks almoſt every kind of ſeed from its concealment in the plant; and not only ſo, but hulls the grain, breaks and ſhatters the coats of the ſeed, in order to get at the kernel. The *hooked* beak of the hawk tribe, ſeparates the fleſh from the bones of the animals which it feeds upon, almoſt with the cleanneſs and preciſion of a diſſector's knife. (The butcher bird, transfixes its prey upon the ſpike of a thorn, whilſt it picks its bones.) In ſome birds of this claſs, we have the *croſs* bill, i. e. both the upper and lower bill hooked, and their tips croſſing. The *ſpoon* bill, enables the gooſe to graze, to collect its food from the bottom of pools, or to ſeek it amidſt the ſoft or liquid ſubſtances with which it is mixed. The *long* tapering bill of the ſnipe and woodcock, penetrates ſtill deeper into moiſt earth, which is the bed in which the food of that ſpecies is lodged. This is exactly the inſtrument which the animal wanted. It did not want ſtrength in its bill, which was inconſiſtent with the ſlender form of the animal's neck, as well as unneceſſary for the kind of aliment upon which it ſubſiſts; but it wanted length to reach its object.

But the ſpecies of bill which belongs to birds that live by *fuction*, deferves to be defcribed in its particular relation to that office. They are what naturalifts call ferrated or dentated bills; the infide of them, towards the edge, being thickly fet with parallel or concentric rows, of fhort, ftrong, fharp-pointed prickles. Thefe, though they fhould be called teeth, are not for the purpofe of maftication, like the teeth of quadrupeds; nor yet, as in fifh, for the feizing and retaining of their prey; but for a quite different ufe. They form a filter. The *duck* by means of them difcuffes the mud; examining, with great accuracy, the puddle, the brake, every mixture which is likely to contain her food. The operation is thus carried on.—The liquid or femiliquid fubftances, in which the animal has plunged her bill, fhe draws, by the action of her lungs, through the narrow interftices which lie between thefe teeth; catching, as the ftream paffes acrofs her beak, whatever it may happen to bring along with it, that proves agreeable to her choice, and eafily difmiffing all the reft. Now fuppofe the purpofe to have been, out of a mafs of confufed and heterogenous fubftances, to feparate for the ufe of the animal, or rather to enable the animal to feparate for its own, thofe few particles which fuited its tafte and digeftion, what more artificial, or more commodious inftrument of felection, could have been given to it, than this natural filter? It has been obferved alfo, what muft enable the bird to choofe and diftinguifh with greater acutenefs, as well, probably, as what increafes its gratification and its luxury, that the bills of this fpecies are furnifhed with large nerves, that they are covered with a fkin, and that the nerves run down to the very extremity. In the curlew, woodcock, and fnipe, there are *three pairs* of nerves, equal almoft to the optic nerve in thicknefs, which pafs firft along the roof of the mouth, and then along the upper chap, down to the point of the bill, long as the bill is.

But to return to the train of our obſervations. The ſimilitude between the bills of birds and the mouths of quadrupeds, is exactly ſuch, as, for the ſake of the argument, might be wiſhed for. It is near enough to ſhew the continuation of the ſame plan: it is remote enough to exclude the ſuppoſition of the difference being produced by action or uſe. A more prominent contour, or a wider gape, might be reſolved into the effect of continued efforts, on the part of the ſpecies, to thruſt out the mouth, or open it to the ſtretch. But by what courſe of action, or exerciſe, or endeavor ſhall we get rid of the lips, the gums, the teeth; and acquire, in the place of them, pincers of horn? By what habit ſhall we ſo completely change, not only the ſhape of the part, but the ſubſtance of which it is compoſed? The truth is, if we had ſeen no other than the mouths of quadrupeds, we ſhould have thought no other could have been formed: little could we have ſuppoſed, that all the purpoſes of a mouth, furniſhed with lips, and armed with teeth, could be anſwered by an inſtrument which had none of theſe; could be ſupplied, and that with many additional advantages, by the hardneſs, and ſharpneſs, and figure, of the bills of birds.

Every thing about the animal *mouth* is mechanical. The teeth of fiſh, have their points turned backwards, like the teeth of a wool or cotton-card. The teeth of lobſters, work one againſt another, like the ſides of a pair of ſhears. In many inſects, the mouth is converted into a pump or ſucker, fitted at the end ſometimes with a wimble, ſometimes with a forceps; by which double proviſion, viz. of the tube and the penetrating form of the point, the inſect firſt bores through the integuments of its prey, and then extracts the juices. And, what is moſt extraordinary of all, one ſort of mouth, as the occaſion requires, ſhall be changed into another ſort. The caterpillar, could not live without teeth ; in ſeveral ſpecies, the butterfly formed from it, could not uſe them. The old teeth therefore are caſt off with the exuviæ of the grub ; a new and totally different apparatus aſſumes their place in the fly. Amidſt theſe novelties of form, we ſometimes forget that it is, all the while, the animal's *mouth;* that, whether it be lips, or teeth, or bill, or beak, or ſhears, or pump, it is the ſame part diverſified : and it is alſo remarkable, that under all the varieties of configuration with which we are acquainted, and which are very great, the organs of taſte and ſmelling are ſituated near each other.

III. To the mouth adjoins the *gullet :* in this part alſo, comparative anatomy diſcovers a difference of ſtructure adapted to the different neceſſities of the animal. In brutes, becauſe the poſture of their neck conduces little to the paſſage of the aliments, the fibres of the gullet, which act in this buſineſs, run in two cloſe ſpiral lines, croſſing each other : in men, theſe fibres run only a little obliquely from the upper end of the œſophagus to the ſtomach, into which, by a gentle contraction, they eaſily tranſmit the deſcending morſels ; that is to ſay, for the more laborious deglutition of animals, which thruſt their food *up* inſtead of *down*, and alſo through a longer paſſage, a proportionably more powerful apparatus of muſcles is provided ; more powerful, not merely by the ſtrength of the fibres, which might be attributed to the greater exercile of their force, but in their collocation, which is a determinate circumſtance, and muſt have been original.

IV. The gullet leads to the *inteſtines :* here, likewiſe, as before, comparing quadrupeds with man, under a general ſimilitude we meet with appropriate differences. The valvulæ conniventes, or, as they are by ſome called, the ſemilunar valves, found in the human inteſtine, are wanting in that of brutes. Theſe are wrinkles or plaits of the innermoſt coat of the guts, the effect of which is to retard the progreſs of the food through the alimentary canal. It is eaſy to underſtand how much more neceſſary ſuch a proviſion may be to the body of an animal of an erect poſture, and in which, conſequently, the weight of the food is added to the action of the inteſtine, than in that of a quadruped, in which the courſe of the food, from its entrance to its exit, is nearly horizontal: but it is impoſſible to aſſign any cauſe, except the final cauſe, for this diſtinction actually taking place. So far as depends upon the action of the part, this ſtructure was more to be expected in a quadruped than a man. In truth, it muſt, in both, have been formed, not by action, but in direct oppoſition to action, and to preſſure: but the oppoſition, which would ariſe from preſſure, is greater in the upright trunk than in any other. That theory therefore is pointedly contradicted by the example before us. The ſtructure is found, where its generation, according to the method by which the theoriſt would have it generated, is the moſt difficult; but *(obſerve)* it is found, where its effect is moſt uſeful.

The different length of the inteſtines in carnivorous and herbivorous animals has been noticed on a former occaſion. The ſhorteſt, I believe, is that of ſome birds of prey, in which the inteſtinal canal is little more than a ſtraight paſſage from the mouth to the vent. The longeſt is in the deer kind. The inteſtines of a Canadian ſtag, four feet high, meaſured ninety-ſix feet.* The inteſtine of a ſheep, unravelled, meaſures thirty times the length of the body. The inteſtine of a wild cat is only three times the length of the body. Univerſally, where the ſubſtance upon which the animal feeds, is of ſlow concoction, or

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

yeldsits chyle with more difficulty, there the paſſage is circuitous and dilatory, that the time and ſpace may be allowed for the change and the abſorption which are neceſſary. Where the food is ſoon diſſolved, or already half aſſimilated, an unneceſſary, or, perhaps, hurtful detention is avoided, by giving to it a ſhorter and a readier route.

V. In comparing the *bones* of different animals, we are ſtruck, in the bones of birds, with a *propriety*, which could only proceed from the wiſdom of an intelligent and deſigning Creator. In the bones of an animal which is to fly, the two qualities required, are ſtrength and lightneſs. Wherein, therefore, do the bones of the birds (I ſpeak of the cylindrical bones) differ, in theſe reſpects, from the bones of quadrupeds? In three properties; firſt, their cavities are much larger in proportion to the weight of the bone, than in thoſe of quadrupeds: ſecondly, theſe cavities are empty: thirdly, the ſhell is of a firmer texture, that is the ſubſtance of other bones. It is eaſy to obſerve theſe particulars, even in picking the wing or leg of a chicken. Now, the weight being the ſame, the diameter, it is evident, will be greater in a hollow bone than a ſolid one; and, with the diameter, as every mathematician can prove, is increaſed, cæteris paribus, the ſtrength of the cylinder, or its reſiſtance to breaking. In a word; a bone of the *ſame weight* would not have been ſo ſtrong in any other form; and, to have made it heavier, would have incommoded the animal's flight. Yet this form could not be acquired by uſe, or the bone become hollow and tubular by exerciſe. What appetency could excavate a bone?

VI. The *lungs* alſo of birds, as compared with the lungs of quadrupeds, contain in them a proviſion, diſtinguiſhingly calculated for this ſame purpoſe of levitation; namely, a communication (not found in other kinds of animals) between the air-veſſels of the lungs and the cavities of the body : ſo that by the intromiſſion of air from one to the other, at the will, as it ſhould ſeem, of the animal, its body can be occaſionally puffed out, and its tendency to deſcend in the air, or its ſpecific gravity, made leſs. The bodies of birds are blown up from their lungs, which no other animal bodies are ; and thus rendered buoyant.

VII. All birds are *oviparous*. This, likewiſe, carries on the work of geſtation, with as little increaſe as poſſible of the weight of the body. A gravid uterus would have been a troubleſome burthen to a bird in its flight. The advantage, in this reſpect, of an oviparous procreation is, that, whilſt the whole brood are hatched together, the eggs are excluded ſingly, and at conſiderable intervals. Ten, fifteen, or twenty young birds may be produced in one cletch or covey, yet the parent bird have never been encumbered by the load of more than one full grown egg at one time.

VIII. A principal topic of compariſon between animals, is in their *inſtruments of motion*. Theſe come before us under three diviſions, feet, wings, and fins. I deſire any man to ſay, which of the three is beſt fitted for its uſe : or whether the ſame conſummate art be not conſpicuous in them all. The conſtitution of the elements, in which the motion is to be performed, is very different. The animal action muſt neceſſarily follow that conſtitution. The Creator therefore, if we might ſo ſpeak, had to prepare for different ſituations, for different difficulties : yet the purpoſe is accompliſhed not leſs ſucceſsfully, in one caſe than the other. And, as between *wings* and the correſponding limbs of quadrupeds, it is accompliſhed without deſerting the general idea. The idea is modified, not deſerted. Strip a wing of its feathers, and it bears no obſcure reſemblance to the fore-leg of a quadruped. The articulations at the ſhoulder and the cubitus are much alike; and, what is a closer circumstance, in both cases the upper part of the limb consists of a single bone, the lower part of two.

But, fitted up with its furniture of feathers and quills, it becomes a wonderful instrument; more artificial than its first appearance indicates, though that be very striking: at least, the use, which the bird makes of its wings in flying, is more complicated, and more curious, than is generally known. One thing is certain; that, if the flapping of the wings in flight were no more than the reciprocal motion of the same surface in opposite directions, either upwards and downwards, or estimated in any oblique line, the bird would lose as much by one motion, as she gained by the other. The sky-lark could never ascend by such an action as this; for, though the stroke upon the air by the under side of her wing would carry her up, the stroke from the upper side, when she raised her wing again, would bring her down. In order, therefore, to account for the advantage which the bird derives from her wings, it is necessary to suppose, that the surface of the wing, measured upon the same plane, is contracted, whilst the wing is drawn up; and let out to its full expansion, when it descends upon the air for the purpose of moving the body by the reaction of that element. Now the form and structure of the wing, its external convexity, the disposition, and particularly the overlapping of its larger feathers, the action of the muscles and joints of the pinions, are all adapted to this alternate adjustment of its shape and dimensions. Such a twist, for instance, or semirotatory motion, is given to the great feathers of the wing, that they strike the air with their flat side, but rise from the stroke slantwise. The turning of the oar in rowing, whilst the rower advances his hand for a new stroke, is a similar operation to that of the feather, and takes its name from the resemblance.

I believe that this faculty is not found in the great feathers of the tail. This is the place also for observing, that the pinions are so set on upon the body, as to bring down the wings, not vertically, but in a direction obliquely tending towards the tail: which motion, by virtue of the common resolution of forces, does two things at the same time; supports the body in the air, and carries it forward.

The *steerage* of a bird in its flight is effected partly by the wings, but, in a principal degree, by the tail. And herein we meet with a circumstance not a little remarkable. Birds with long legs have short tails; and, in their flight, place their legs close to their bodies, at the same time stretching them out backwards as far as they can. In this position the legs extend beyond the rump, and become the rudder; supplying that steerage which the tail could not.

From the *wings* of birds, the transition is easy to the *fins* of fish. They are both, to their respective tribes, the instruments of their motion; but, in the work which they have to do, there is a considerable difference, founded in this circumstance. Fish, unlike birds, have very nearly the same specific gravity with the element in which they move. In the case of fish, therefore, there is little or no weight to bear up: what is wanted, is only an impulse sufficient to carry the body through a resisting medium, or to maintain the posture, or to support, or restore the balance of the body, which is always the most unsteady where there is no weight to sink it. For these offices the fins are as large as necessary, though much smaller than wings, their action mechanical, their position, and the muscles by which they are moved, in the highest degree, convenient. The following short account of some experiments upon fish, made for the purpose of ascertaining the use of their fins, will be the best confirmation of what we assert. In most fish, beſide the great fin the tail, we find two pair of fins upon the ſides, two ſingle fins upon the back, and one upon the belly, or rather between the belly and the tail. The *balancing* uſe of theſe organs is proved in this manner. Of the large headed fiſh, if you cut off the pectoral fins, i. e. the pair which lies cloſe behind the gills, the head falls prone to the bottom: if the right pectoral fin only be cut off, the fiſh leans to that ſide; if the ventral fin on the ſame ſide be cut away, then it loſes its equilibrium entirely: if the dorſal and ventral fins be cut off, the fiſh reels to the right and left. When the fiſh dies, that is, when the fins ceaſe to play, the belly turns upwards. The uſe of the ſame parts for *motion* is ſeen in the following obſervation upon them when put in action. The pectoral, and more particularly the ventral fins, ſerve to *raiſe and depreſs* the fiſh: when the fiſh deſires to have a *retrograde* motion, a ſtroke forward with the pectoral fin effectually produces it: if the fiſh deſire to *turn* either way, a ſingle blow with the tail the oppoſite way, ſends it round at once: if the tail ſtrike both ways, the motion produced by the double laſh is *progreſſive*; and enables the fiſh to dart forwards with an aſtoniſhing velocity.* The reſult is, not only, in ſome caſes, the moſt rapid, but, in all caſes, the moſt gentle, pliant, eaſy, animal motion, with which we are acquainted. However, when the tail is cut off, the fiſh loſes all motion, and gives itſelf up to where the water impels it. The reſt of the fins, therefore, ſo far as reſpects motion, ſeem to be merely ſubſidiary to this. In their mechanical uſe, the anal fin may be reckoned the keel, the ventral fins, out-riggers; the pectoral fins, the oars: and if there be any ſimilitude between theſe parts of a boat and a fiſh, obſerve, that it is not the reſemblance of imitation, but

* Goldſmith's Hiſt. of An. Nat. vol. vi. p. 154.

the likeneſs which ariſes from applying ſimilar mechanical means to the ſame purpoſe.

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

Regarding animals in their inſtruments of motion, we have only followed the compariſon through the firſt great diviſion of animals into beaſts, birds, and fiſh. If it were our intention to purſue the conſideration further, I ſhould take in that generic diſtinction among birds, the *web foot* of water fowl. It is an inſtance which may be pointed out to a child. The utility of the web to water fowl, the inutility to land fowl, are ſo obvious, that it ſeems impoſſible to notice the difference without acknowledging the deſign. I am at a loſs to know, how thoſe who deny the agency of an intelligent Creator, diſpoſe of this example. There is nothing in the action of ſwimming, as carried on by a bird upon the ſurface of the water, that ſhould generate a membrane between the toes: As to that membrane, it is an exerciſe of conſtant reſiſtance. The only ſuppoſition I can think of is, that all birds have been originally water fowl, and web footed; that ſparrows, hawks, linnets, &c. which frequent the land, have, in proceſs of time, and in the courſe of many generations, had this part worn away by treading upon hard ground. To ſuch evaſive aſſumptions muſt atheiſm always have recourſe; and, after all, it confeſſes that the ſtructure of the feet of birds, in their original form, was critically adapted to their original deſtination. The web feet of amphibious quadrupeds, ſeals, otters, &c. fall under the ſame obſervation.

IX. The *five senses* are common to most large animals: nor have we much difference to remark in their constitution; or much however which is referable to mechanism.

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

The external *ears* of beasts of prey, of lions, tigers, wolves, have their trumpet part or concavity standing forwards, 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, when 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 continued 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 affected 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 collect under this title, might, conſiſtently enough with technical language, have been placed under the head of *Comparative Anatomy*. But there appears to me an impropriety in the uſe which that term hath obtained: it being, in ſome ſort, abſurd, to call that a caſe of comparative anatomy, in which there is nothing to "compare;" in which a conformation is found in one animal, which hath nothing properly anſwering to it in another. Of this kind are the examples which I have to propoſe in the preſent chapter; and the reader will ſee, that though ſome of them be the ſtrongeſt, perhaps, he will meet with under any diviſion of our ſubject, they muſt neceſſarily be of an unconnected and miſcellaneous nature. To diſpoſe them however into ſome ſort of order, we will notice, firſt, particularities of ſtructure which belong to quadrupeds, birds, and fiſh, as ſuch, or to many of the kinds included in theſe claſſes of animals; and then, ſuch particularities as are confined to one or two pecies.

I. Along each ſide of the neck of large *quadrupeds*, runs a ſtiff robuſt cartilage, which butchers call the pax wax. No perſon can carve the upper end of a crop of beef without driving his knife againſt it. It is a tough, ſtrong, tendinous ſubſtance, braced from the head to the middle of the back: its office is to aſſiſt in ſupporting the weight of the head. It is a mechanical proviſion, of which this is the undiſputed uſe; and it is ſufficient, and no more than ſufficient, for the purpoſe which it has to execute. The head of an ox or a horſe is a heavy weight, acting at the end of a long lever, (conſequently with a great purchaſe,) and in a direction nearly perpendicular to the joints of the ſupporting neck. From ſuch a force, ſo advantageouſly applied, the bones of the neck would be in conſtant danger of diſlocation, if they were not fortified by this ſtrong tape. No ſuch organ is found in the human ſubject, becauſe, from the erect poſition of the head, (the preſſure of it acting nearly in the direction of the ſpine,) the junction of the vertebræ appears to be ſufficiently ſecure without it. The care of the Creator is ſeen where it is wanted. This cautionary expedient is limited to quadrupeds.

II. The oil with which *birds* prune their feathers, and the organ which ſupplies it, is a ſpecific proviſion for the winged creation. On one ſide of the rump of birds, is obſerved a ſmall nipple, yielding, upon preſſure, a butter-like ſubſtance, which the bird extracts by pinching the pap with its bill. With this oil or ointment, thus procured, the bird dreſſes its coat; and repeats the action as often as its own ſenſations teach 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 lodgment 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, ſkaits, 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 the 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 incloſed, 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 diſtenſion 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 in the machine; why the argument is not as firm, in one caſe as the other.

It would be very worthy of enquiry, 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. Nothing ſimilar to the air bladder is found in land animals; and a life in the water has no natural tendency to produce a bag of air. Nothing can be further from an acquired organization than this is.

Theſe examples mark the attention of the Creator to three great kingdoms of his animal creation, and to their conſtitution as ſuch. The example which ſtands next in point of generality, belonging to a large tribe of animals, or rather to various ſpecies of that tribe, 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 tooth, looſe at the root; in its quiet ſtate lying down flat upon the jaw, but furniſhed with a muſcle, which, with a jerk, and by the pluck as it were of a ſtring, ſuddenly erects it. Under the tooth, cloſe to its root, and communicating with the perforation, lies a ſmall bag containing the venom. When the fang is raiſed, the cloſing of the jaw preſſes its root againſt the bag underneath ; and the force of this compreſſion ſends out the fluid, and with a conſiderable impetus, through the tube in the middle of the tooth. What more unequivocal or effectual apparatus could be deviſed, for the double 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 conveyance, and their aſylum. Can the uſe of this ſtructure be doubted of ? Nor is it a mere doubling of the ſkin, but it 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 ſpecies than one; and alſo as ſtrictly mechanical; we may notice a circumſtance in the ſtructure of the *claws* of certain birds. The middle claw of the heron and cormorant is toothed and notched like a ſaw. Theſe birds are great fiſhers, and theſe notches aſſiſt them in holding their ſlippery prey. The uſe is evident; but the ſtructure ſuch, as cannot at all be accounted for by the effort of the animal, or the exerciſe of the part. Some other fiſhing birds have theſe notches in their *bills;* and for the ſame purpoſe. The gannet, or Soland gooſe, has the ſide of its bill irregularly jagged, that it may hold its prey the faſter. Nor can the ſtructure in this, more than in the former caſe, ariſe from the manner of employing the part. The ſmooth ſurfaces, and ſoft fleſh of fiſh, were leſs likely to notch the bills of birds, than the hard bodies upon which many other ſpecies feed.

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

I. The *ſtomach of the camel* is well known to retain large quantities of water, and to retain it unchanged for a conſiderable length of time. This property qualifies it for living in the deſart. 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 between the membranes of the ſecond ſtomach, and to

* Goldſmith's Nat. Hiſt. vol. iv. p. 244.

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 the 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 elſe but 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 uſe. The bird, having expoſed the retreats of the inſects by the aſſiſtance of its bill, with a motion inconceivably quick lanches 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 mechanifm, what is? Should it be faid, that, by continual endeavors to fhoot out the tongue to the ftretch, the woodpecker fpecies may by degrees have lengthened the organ itfelf, beyond that of other birds, what account can be given of its form; of its tip? How, in particular, did it get its barbs, its dentition? Thefe barbs, in my opinion, wherever they occur, are decifive proofs of mechanical contrivance.

III. I fhall add one more example for the fake of its novelty. It is always an agreeable difcovery, when, having remarked in an animal an extraordinary ftructure, we come at length to find out an unexpected ufe for it. The following narrative, which Goldfmith has taken from Buffon, furnifhes an inftance of this kind. The babyrouefsa, or Indian hog, a fpecies of wild boar found in the Eaft-Indies, has two *bent* teeth, more than half a yard long, growing upwards, and, which is the fingularity, from the upper jaw. Thefe inftruments are not wanted for defence, that fervice being provided for by two tufks iffuing from the under jaw, and refembling thofe of the common boar. Nor does the animal ufe them for defence. They might feem therefore to be both a fuperfluity and an incumbrance. But obferve the event. The animal hitches one of thefe bent upper teeth upon the branch of a tree, and then fuffers its whole body to fwing from it. This is its manner of taking repofe, and of confulting for its fafety. It continues the whole night fufpended by its tooth, both eafy in its pofture, and fecure; being out of the reach of animals which hunt it for prey.*

* Goldfmith's Nat. Hift. vol iii. p. 195.

CHAPTER XIV.

PROSPECTIVE CONTRIVANCES.

I CAN hardly imagine to myself a more distinguishing mark, and, consequently, a more certain proof of design, than *preparation*, i. e. the providing of things beforehand, which are not to be used until a considerable time afterwards; for this implies a contemplation of the future, which belongs only to intelligence.

Of these prospective contrivances the bodies of animals furnish various examples.

I. The human teeth afford an instance, not only of prospective contrivance, but of the completion of the contrivance being designedly suspended. They are formed within the gums, and there they stop: the fact being, that their further advance to maturity would not only be useless to the new-born animal, but extremely in its way; as it is evident that the act of *sucking*, by which it is for some time to be nourished, will be performed with more ease both to the nurse and to the infant, whilst the inside of the mouth, and edges of the gums, are smooth and soft, than if set with hard pointed bones. By the time they are wanted, the teeth are ready. They have been lodged within the gums for some months past, but detained, as it were, in their sockets, so long as their further protrusion would interfere with the office to which the mouth is destined. Nature, namely, that intelligence which was employed in creation, looked beyond the first year 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 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 further. 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 unſurmountable. 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 œconomy 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 chymistry 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 it: 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 of nourishment in one part of the system, there would be the least likelihood of a redundancy to support 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 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 circumstances 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 the 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 lense 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 exclusion 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 endeavour, 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 is, actually, done in the heart. Inſtead of the circuitous route through the lungs, which the blood afterwards takes, before it get from one auricle of the heart to the other; a portion of the blood paſſes immediately from the right auricle to the left, through a hole, placed in the partition, which ſeparates theſe cavities. This hole anatomiſts call the *foramen ovale.* There is likewiſe another croſs cut, anſwering the ſame purpoſe, by what is called the *ductus arterioſus*, lying between the pulmonary artery and the aorta. But both expedients are ſo ſtrictly temporary, that, after birth, the one paſſage is cloſed, and the tube which forms the other, ſhrivelled up into a ligament. If this be not contrivance, what is?

But, foraſmuch as the action of the air upon the blood in the lungs, appears to be neceſſary to the perfect concoction of that fluid, i. e. to the life and health of the animal, (otherwiſe the ſhorteſt route might ſtill 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 has undergone that action in her habit; that one pair of lungs ſerves for both. When the animals are ſeparated, a new neceſſity ariſes; and to meet this neceſſity as ſoon as it occurs, an organization is prepared. It is 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; or, which is the ſame thing, when an effect is produced by the joint action of different inſtruments; the fitneſs of ſuch parts or inſtruments to one another, for the purpoſe of producing, by their united action, the effect, is what I call *relation:* and wherever this is obſerved in the works of nature or of man, it appears to me to carry along with it deciſive evidence of underſtanding, intention, art. In examining, for inſtance, the ſeveral parts of a *watch*, the ſpring, the barrel, the chain, the fuſee, the balance, the wheels of various ſizes, forms, and poſitions, what is it which would take the obſerver's attention, as moſt plainly evincing a conſtruction, directed by thought, deliberation, and contrivance? It is the ſuitableneſs of theſe parts to one another, firſt, in the ſucceſſion and order in which they act; and, ſecondly, with a view to the effect finally produced. Thus, referring the ſpring to the wheels, he ſees, in it, that which originates and upholds *their* motion; in the chain, that which tranſmits the motion to the fuſee; in the fuſee, that which communicates it to the wheels; in the conical figure of the fuſee, if he refer back again to the ſpring, he ſees that which corrects the inequality of its force. Referring the wheels to one another, he notices, firſt, their teeth, which would have been without uſe or meaning, if there had been only one wheel, or if the wheels had had no connexion between themſelves, or common bearing upon ſome joint effect; ſecondly, the correſpondency of their poſition, ſo that the teeth of one wheel catch into the teeth of another; thirdly, the proportion obſerved in the number of teeth of each wheel, which determines the rate of going. Referring the balance to the reft of the works, he faw, when he came to underftand its action, that which rendered their motions equable. Laftly, in looking upon the index and face of the watch, he faw the ufe and conclufion of the mechanifm, viz. marking the fucceffion of minutes and hours; but all depending upon the motions within, all upon the fyftem of intermediate actions between the fpring and the pointer. What thus ftruck his attention in the feveral parts of the watch he might probably defignate by one general name of "relation:" and obferving, with refpect to all the cafes whatever, in which the origin and formation of a thing could be afcertained by evidence, that thefe relations were found in things produced by art and defign, and in no other things, he would rightly deem of them as characteriftic of fuch productions. To apply the reafoning here defcribed to the works of nature:

The animal œconomy is full; is made up of thefe *relations*.

I. There are firft, what, in one form or other, belong to all animals, the parts and powers which fucceffively act upon their *food*. Compare this action with the procefs of a manufactory. In man and quadrupeds, the aliment is, firft, broken and bruifed by mechanical inftruments of maftication, viz. fharp fpikes or hard knobs, preffing againft, or rubbing upon, one another: thus ground and comminuted, it is carried by a pipe into the ftomach, where it waits to undergo a great chymical action, which we call digeftion: when digefted, it is delivered through an orifice, which opens and fhuts as there is occafion, into the firft inteftine: there, after being mixed with certain proper ingredients, poured through a hole in the fide of the veffel, it is further diffolved: in this ftate, the milk, chyle, or part which is wanted, and which is suited for animal nourishment, is strained off by the mouths of very small tubes, opening into the cavity of the intestines: thus freed from its grosser parts, the percolated fluid is carried by a long, winding, but traceable course, into the main stream of the old circulation; which conveys it, in its progress, to every part of the body. Now I say again, compare this with the process of a manufactory; with the making of cyder, for example, the bruising of the apples in the mill, the squeezing of them when so bruised in the press, the fermentation in the vat, the bestowing of the liquor thus fermented in the hogsheads, the drawing off into bottles, the pouring out for use into the glass. Let any one shew me any difference between these two cases, as to the point of contrivance. That which is at present under our consideration, the "relation" of the parts successively employed, is not more clear in the last case, than in the first. The aptness of the jaws and teeth to prepare the food for the stomach, is, at least, as manifest, as that of the cyder-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 cyder from one vessel to another, of 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 the corn; which receiver, although the corn be put into it by 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; 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

* Diſſ. I. ſec. liv.

ſtill more particular. The gaſtric juice even of graminivorous birds, will not act upon the grain, whilſt whole and entire. In performing the experiment of digeſtion 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 is the relation between the offices aſſigned to the digeſtive organ; between the mechanical operation, and the chymical 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 œconomy. 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 the compaſs out of four to have erred in. Any conſiderable alteration in the poſition of the eye, or the figure of the joints, would have diſturbed the line, and deſtroyed 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 ſame thing, but between different things. The relation between a lock and a key is more obvious, than it is between different parts of the lock. A bow was deſigned for an arrow, and an arrow for a bow; and the deſign is more evident for their being ſeparate implements.

Nor do the works of the Deity want this cleareſt ſpecies of relation. The *ſexes* are manifeſtly made for each other. They form the grand relation of animated nature; univerſal, organic, mechanical; ſubſiſting, like the cleareſt relations of art, in different individuals; unequivocal, inexplicable without deſign:

So much ſo, that, were every other proof of contrivance in nature dubious or obſcure, this alone would be ſufficient. The example is complete. Nothing is wanting to the argument. I ſee no way whatever of getting over it.

V. The teats of animals, which give ſuck, bear a relation to the mouth of the ſuckling progeny; particularly to the lips and tongue. Here, alſo, as before, is a correſpondency of parts; which parts ſubſiſt in different 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 gizzard, calculated for the moiſtening, bruiſing, and afterwards digeſting, of vegetable aliment.

Or ſet off with any other diſtinctive part in the body of the ſwan; for inſtance, with the long neck. The long neck, without the web foot, would have been an incumbrance to the bird; yet there is no neceſſary connexion between a long neck and a web foot. In fact they do not uſually go together. How happens it, therefore, that they meet only when a particular deſign demands the aid of both?

II. This mutual relation, ariſing from a ſubſerviency to a common purpoſe, is very obſervable alſo in the parts of a *mole*. The ſtrong ſhort legs of that animal, the palmated feet armed with ſharp nails, the piglike noſe, the teeth, the velvet coat, the ſmall external ear, the ſagacious ſmell, the ſunk protected eye, all conduce to the utilities, or to the ſafety, of its underground life. It is a ſpecial purpoſe, ſpecially conſulted throughout. The form of the feet fixes the character of the animal. They are ſo many ſhovels: they determine its action to that of rooting in the ground; and every thing about its body agrees with this deſtination. The cylindrical figure of the mole, as well as the compactneſs of its form, ariſing from the terſeneſs of its limbs, proportionally leſſens its labour; becauſe, according to its bulk, it thereby requires the leaſt poſſible quantity of earth to be removed for its progreſs. It has nearly the ſame ſtructure of the face and jaws as a ſwine, and the ſame office for them. The noſe is ſharp, ſlender, tendinous, ſtrong; with a pair of nerves going down to the end of it. The pluſh covering, which, by the ſmoothneſs, cloſeneſs, and poliſh of the ſhort piles 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 mold 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 deep 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 connexion 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 ſet 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 its 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 underground 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 there-fore, in ſome reſpects neceſſary, but in ſome reſpects alſo inadequate to the occaſions of the animal, a ſupplement is added, which exactly makes up the deficiency under which he laboured.

If it be ſuggeſted, that this proboſcis may have been produced in a long courſe of generations, by the conſtant endeavour of the elephant to thruſt out his 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 webb feet, are incapable of ſwimming. To make up for 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 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 moveable, 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. This great defect is however perfectly *compensated;* and by a mechanism which we should not suspect. The eye is a multiplying glass; with a lense 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 multiplicity and minuteness of the surfaces must have added to the surprise of the discovery. Adams tells us, that fourteen hundred of the 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,

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

which the wants or safety of the animal render 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 camelion. Instead of two eyelids 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 camelion 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 more than ordinary supply of moisture; yet the motion of an 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 due 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 œconomy, the same Memoirs describe a most remarkable *substitution*. The reader will remember what we have already observed concerning the *intestinal* canal; that its length, so many times exceeding that of the body, promotes the extraction of the chyle from the aliment, by giving room for the lacteal vessels to act upon it through a greater space. This long intestine, wherever it occurs, is, in other animals, diſpoſed in 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 mechanically effectuated; but by a mechaniſm of a different kind. The animal of which I ſpeak, is an amphibious quadruped, which our authors call the alopecias, or ſea-fox. The inteſtine is ſtraight from one end to the other: but in this ſtraight, and conſequently, ſhort inteſtine, is a winding, cork-ſcrew, ſpiral paſſage, through which, the food, not without ſeveral circumvolutions, and in fact by a long route, is conducted to its exit. Here the ſhortneſs of the gut is *compenſated* by the obliquity of the perforation.

IX. But the works of the Deity are known by expedients. Where we ſhould look for abſolute deſtitution; where we can reckon up nothing but wants; ſome contrivance always comes in to ſupply the privation. A *ſnail*, without wings, feet, or thread, climbs up the ſtalks of plants, by the ſole aid of a viſcid humour diſcharged from her ſkin. She adheres to the ſtems, leaves, and fruits of plants, by means of a ſticking plaiſter. A *muſcle*, which might ſeem, by its helpleſſneſs, to lie at the mercy of every wave that went over it, has the ſingular power of ſpinning ſtrong, tendinous threads, by which ſhe moors her ſhell to rocks and timbers. A *cockle*, on the contrary, by means of its ſtiff tongue, works for itſelf a ſhelter in the ſand. The proviſions of nature extend to caſes the moſt deſperate. A *lobſter*, has a difficulty in its conſtitution ſo great, that one could hardly conjecture before hand how nature would diſpoſe of it. In moſt animals, the ſkin grows with their growth. If, inſtead of a ſoft ſkin, there be a ſhell, ſtill it admits of a gradual enlargement. If the ſhell, as in the tortoiſe, conſiſt of ſeveral pieces, the acceſſion of ſubſtance is made at the ſutures. Bivalve shells grow bigger by receiving an accretion at their edge: it is the same with spiral shells at their mouth. The simplicity of their form admits of this. But the lobster's shell being applied to the limbs of the body, as well as to the body itself, allows not of either of the modes of growth which are observed to take place in other shells. Its hardness resists expansion; and its complexity renders it incapable of increasing its size by addition of substance to its edge. How then was the growth of the lobster to be provided for? Was room to be made for it in the old shell, or was it to be successively fitted with new ones? If a change of shell become necessary, how was the lobster to extricate himself from his present confinement? How was he to uncase his buckler, or draw his legs out of his boots? The process, which fishermen have observed to take place, is as follows. At certain seasons, the shell of the lobster grows soft; the animal swells its body; the seams open, and the claws burst at the joints. When the shell is thus become loose upon the body, the animal makes a second effort, and by a tremulous, spasmodic motion, casts it off. In this state the liberated, but defenceless fish, retires into holes in the rock. The released body now suddenly pushes its growth. In about eight-and-forty hours, a fresh concretion of humour upon the surface, i. e. a new shell, is formed, adapted in every part to the increased dimensions of the animal. This wonderful mutation is repeated every year.

If there be imputed defects without compensation, I should suspect that they were defects only in appearance. Thus, the body of the *sloth* has often been reproached for the slowness of its motions, which has been attributed to an imperfection in the formation of its limbs. But it ought to be observed, that it is this slowness, which alone suspends the voracity of the animal. He fasts during his migration from one tree to another; and this faſt may be neceſſary for the relief of his overcharged veſſels, as well as to allow time for the concoction of the maſs of coarſe and hard food which he has taken into his ſtomach.— The tardineſs of his pace ſeems to have reference to the capacity of his organs, and to his propenſities with reſpect to food: i. e. is calculated to counteract the effects of repletion.

Or there may be caſes, in which a defect is artificial, and compenſated by the very cauſe which produces it. Thus the *ſheep*, in the domeſticated ſtate in which we ſee it, is deſtitute of the ordinary means of defence or eſcape; is incapable either of reſiſtance or flight. But this is not ſo with the wild animal. The natural ſheep is ſwift and active; and, if it loſe their qualities when it comes under the ſubjection of man, the loſs is compenſated by his protection. Perhaps there is no ſpecies of quadrupeds whatever, which ſuffer ſo little as this does, from the depredation of animals of prey.

For the ſake of making our meaning better underſtood, we have conſidered this buſineſs of compenſation under certain *particularities* of conſtitution, in which it appears to be moſt conſpicuous. This view of the ſubject neceſſarily limits the inſtances to ſingle ſpecies of animals. But there are compenſations, perhaps, not leſs certain, which extend over large claſſes, and to large portions, of living nature.

I. In quadrupeds, the deficiency of teeth is uſually *compenſated* by the faculty of rumination. The ſheep, deer, and ox tribe, are without fore teeth in the upper jaw. Theſe ruminate. The horſe and aſs are furniſhed with teeth in the upper jaw, and do not ruminate. In the former claſs the graſs and hay deſcend into the ſtomach, nearly in the ſtate in which they are cropped in the paſture, or gathered from the bundle. In the ſtomach they are ſoftened by the gaſtric juice, which in theſe animals is unuſually copious. Thus ſoftened, and rendered tender, they are returned a ſecond time to the action of the mouth, where the grinding teeth complete at their leiſure the trituration which is neceſſary, but which was before left imperfect. I ſay the trituration which is neceſſary; for it appears from experiments that the gaſtric fluid of ſheep, for example, has no effect in digeſting plants, unleſs they have been previouſly maſticated; that it only produces a ſlight maceration, nearly as common water would do in a like degree of heat: but that, when once vegetables are reduced to pieces by maſtication, the fluid then exerts upon them its ſpecific operation. Its firſt effect is to ſoften them, and to deſtroy their natural conſiſtency: it then goes on to diſſolve them; not ſparing even the toughcſt parts, ſuch as the nerves of the leaves.*

I think it very probable that the gratification alſo of the animal is renewed and prolonged by this faculty. Sheep, dear, and oxen, appear to be in a ſtate of enjoyment whilſt they are chewing the cud. It is then, perhaps, 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 make up for this ſevere want? I ſpeak of graminivorous and herbivorous birds; ſuch as common fowls, turkeys, ducks, geeſe, pigeons, &c. for it is concerning theſe alone that the queſtion need be aſked. All theſe are furniſhed with a peculiar and moſt powerful muſcle, called the *gizzard;* the inner coat of which is fitted up with rough plaits, which, by a ſtrong friction againſt one another, break and grind the hard aliment, as effectually, and by the ſame mechanical action, as a coffe-mill would do. It has been proved by the moſt correct experiments, that the gaſtric juice

* Spal. Diſſ. III. ſec. cxl.

of theſe birds will not operate upon the *entire* grain; not even when ſoftened by water or macerated in the crop. Therefore without a grinding machine within its body; without the trituration of the gizzard; a chicken would have ſtarved upon a heap of corn. Yet why ſhould a bill and a gizzard go together? Why ſhould a gizzard never be found where there are teeth?

Nor does the gizzard belong to birds as ſuch. A gizzard is not found in birds of prey. *Their* food requires not to be ground down in a mill. The compenſatory contrivance goes no further than the neceſſity. In both claſſes of birds, however, the digeſtive organ within the body, bears a ſtrict and mechanical relation to the external inſtruments for procuring food. The ſoft membranous ſtomach, accompanies the hooked, notched, beak; the ſhort, muſcular legs; the ſtrong, ſharp, crooked talons; the cartilaginous ſtomach, attends that conformation of bill and toes, which reſtrains the bird to the picking of ſeeds or the cropping of plants.

III. But to proceed with our *compenſations*. A very numerous and comprehenſive tribe of terreſtrial animals are entirely without feet; yet locomotive; and, in a very conſiderable degree, ſwift in their motion. How is the *want of feet* compenſated? It is done by the diſpoſition of the muſcles and fibres of the trunk. In conſequence of the juſt collocation, and by means of the joint action of longitudinal and annular fibres, that is to ſay, of ſtrings and rings, the body and train of reptiles are capable of being reciprocally ſhortened and lengthened, drawn up and ſtretched out. The reſult of this action is a progreſſive, and, in ſome caſes, a rapid movement of the whole body, in any direction to which the will of the animal determines it. The meaneſt creature is a collection of wonders. The play of the rings in an earth-worm, as it crawls; the undulatory motion propagated along the body; the beards or prickles, with which the annuli are armed, and which the animal can either ſhut up cloſe to its body, or let out to lay hold of the roughneſſes of the ſurface upon which it creeps; and, the power ariſing from all theſe, of changing its place and poſition, affords, when compared with the proviſions for motion in other animals, proofs of new and appropriate mechaniſm. Suppoſe that we had never ſeen an animal move upon the ground without feet, and that the problem was, muſcular action, i. e. reciprocal contraction and relaxation being given, to deſcribe how ſuch an animal might be conſtructed, capable of voluntarily changing place. Something, perhaps, like the organization of reptiles, might have been hit upon by the ingenuity of an artiſt; or might have been exhibited in an automaton, by the combination of ſprings, ſpiral wires, and ringlets: but to the ſolution of the problem would not be denied, ſurely, the praiſe of invention and of ſucceſsful thought; leaſt of all could it ever be queſtioned, whether intelligence had been employed about it, or not.

CHAPTER XVII.

THE RELATION OF ANIMATED BODIES TO INANIMATE NATURE.

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

But the bodies of animals hold, in their conſtitution and properties, a cloſe and important relation to natures altogether external to their own ; to inanimate ſubſtances, and to the ſpecific qualities of theſe, e. g. *they hold a ſtrict relation to the elements by which they are ſurrounded.*

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

II. The ſtructure of the animal *ear* depends for its uſe not ſimply upon being ſurrounded by a fluid, but upon the ſpecific nature of that fluid. Every fluid would not ſerve : its particles muſt repel one another ; it muſt form an elaſtic medium : for it is by the ſucceſſive pulſes of *ſuch* a medium, that the undulations excited by the ſounding body are carried to the organ ; that a communication is formed between the object and the ſenſe ; which muſt be done, before the internal machinery of the ear, ſubtile as it is, can act at all.

III. The *organs* of ſpeech, and voice, and reſpiration, are, no leſs than the ear, indebted, for the ſucceſs of their operation, to the peculiar qualities of the fluid, in which the animal is immerſed. They, therefore, as well as the ear, are conſtituted upon the ſuppoſition of ſuch a fluid, i. e. of a fluid with ſuch particular properties, being always preſent. Change the properties of the fluid, and the organ cannot act : change the organ, and the properties of the fluid would be loſt. The ſtructure therefore of our organs, and the properties of our atmoſphere, are made for one another. Nor does it alter the relation, whether you alledge the organ to be made for the element, (which ſeems the moſt natural way of conſidering it,) or the element as prepared for the organ.

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

Yet the element of light and the organ of vision, however related in their office and use, have no connexion whatever in their original. The action of rays of light upon the surfaces of animals has no tendency to breed eyes in their heads. The sun might shine for ever upon living bodies without the smallest approach towards producing the sense of sight. On the other hand also, the animal eye does *not* generate or emit light.

V. Throughout the universe there is a wonderful *proportioning* of one thing to another. The size of animals, of the human animal especially, when considered with respect to other animals, or to the plants which grow around him, is such, as a regard to his conveniency would have pointed out. A giant or a pigmy could not have milked goats, reaped corn, or mowed grass; we may add, could not have rode a horse, trained a vine, shorn a sheep, with the same bodily ease as we do, if at all. A pigmy would have been lost amongst rushes, or carried off by birds of prey.

It may be mentioned likewife, that, the model and the materials of the human body being what they are, a much greater bulk would have broken down by its own weight. The perfons of men, who much exceed the ordinary ftature, betray this tendency.

VI. Again; and which includes a vaft variety of particulars, and thofe of the greateft importance, how clofe is the *fuitablenefs* of the earth and fea to their feveral inhabitants; and of thefe inhabitants to the places of their appointed refidence?

Take the *earth* as it is; and confider the correfpondency of the powers of its inhabitants with the properties and condition of the foil which they tread. Take the inhabitants as they are; and confider the fubftances which the earth yields for their ufe. They can fcratch its furface, and its furface fupplies all which they want. This is the length of their faculties; and fuch is the conftitution of the globe, and their own, that this is fufficient for all their occafions.

When we pafs from the earth to the *fea*, from land to water, we pafs through a great change; but an adequate change accompanies us of animal forms and functions, of animal capacities and wants, fo that *correfpondency* remains. The earth in its nature is very different from the fea, and the fea from the earth; but one accords with its inhabitants, as exactly as the other.

VII. The laft relation of this kind which I fhall mention is that of *fleep* to *night*. And it appears to me to be a relation which was exprefsly intended. Two points are manifeft: firft, that the animal frame requires fleep; fecondly, that night brings with it a filence, and a ceffation of activity, which allows of fleep being taken without interruption, and without lofs. Animal exiftence is made up of action and flumber: nature has provided for each. An animal, which ftood not in need of reft, would always live in day-light. An animal, which, though made for action, and delighting 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 the buſtle, the labour, the motion of life, upheld by the conſtant preſence of light, ſleep could not be enjoyed without being diſturbed by noiſe, and without expence of that time, which the eagerneſs of private intereſt would not contentedly reſign. It is happy therefore for this part of the creation, I mean that it is conformable to the frame and wants of their conſtitution, that nature, by the very diſpoſition of her elements, has commanded, as it were, and impoſed upon them, at moderate intervals, a general intermiſſion of their toils, their occupations, and purſuits.

But it is not for man, either ſolely or principally, that night is made. Inferior, but leſs perverted natures, taſte its ſolace, and expect its return, with greater exactneſs and advantage than he does. I have often obſerved, and never obſerved but to admire, the ſatisfaction no leſs than the regularity, with which the greateſt part of the irrational world yield to this ſoft neceſſity, this grateful viciſſitude; how comfortably, the birds of the air, for example, addreſs themſelves to the repoſe of the evening; with what alertneſs they reſume the activity of the day.

Nor does it diſturb our argument to confeſs, that certain ſpecies of animals are in motion during the night, and at reſt in the day. With reſpect even to them it is ſtill true, that there is a change of condition in the animal, and an external change correſponding with it There is ſtill the relation, though inverted. The fact is, that the repoſe of other animals ſets theſe at liberty, and invites them to their food or their ſport.

If the relation of *ſleep* to *night*, and, in ſome inſtances, its converſe, be real, we cannot reflect without amazement upon the extent to which it carries us. Day and night are things close to us: the change applies immediately to our sensations: of all the phænomena of nature, it is the most familiar to our experience: but, in its cause, it belongs to the great motions which are passing in the heavens. Whilst the earth glides round her axle, she ministers to the alternate necessities of the animals dwelling upon her surface, at the same time that she obeys the influence 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 more: it is a relation to the system, of which that globe is a part; and, still further, to the congregation of systems, of which theirs is only one. If this account be true, it connects the meanest individual with the universe itself; a chicken roosting upon its perch, with the spheres revolving in the firmament.

But if any one object to our representation, that the succession of day and night, or the rotation of the earth upon which it depends, is not resolvible into central attraction, we will refer him to that which certainly is—to the change of the seasons. Now the constitution of animals susceptible of torpor, bears a relation 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 quadruped is directed to the teat of its dam; that birds build their neſts, and brood with ſo much patience upon their eggs; that inſects, which do not ſit upon their eggs, depoſit them in thoſe particular ſituations, in which the young, when hatched, find their appropriate food; that it is inſtinct, which carries the ſalmon, and ſome other fiſh, out of the ſea into rivers, for the purpoſe of ſhedding their ſpawn in freſh water.

We may ſelect out of *this* catalogue the incubation of eggs. I entertain no doubt, but that a couple of ſparrows hatched in an oven, and kept ſeparate from the reſt of their ſpecies, would proceed as other ſparrows do, in every office which related to the production and preſervation of their brood. Aſſuming this fact, the thing is inexplicable upon any other hypotheſis, than that of an inſtinct, impreſſed upon the conſtitution of the animal. For, firſt, what ſhould induce the female bird to prepare a neſt before ſhe lays her eggs? It is in vain to ſuppoſe her to be poſſeſſed of the faculty of reaſoning; for no reaſoning will reach the caſe. The fullneſs or diſtenſion which ſhe might feel in a particular part of her body, from the growth and ſolidity of the egg within her, could not poſſibly inform her, that ſhe was about to produce ſomething, which, when produced, was to be preſerved and taken care of. Prior to experience, there was nothing to lead to this inference, or to this ſuſpicion. The analogy was *all* againſt it; for, in every other inſtance, what iſſued from the body was caſt out and rejected.

But, ſecondly, let us ſuppoſe the egg to be produced into day: How ſhould birds know that their eggs contain their young? There is nothing either in the aſpect, or in the internal compoſition of an egg, which could lead even the moſt daring imagination to a conjecture, that it was hereafter to turn out, from under its ſhell, a living perfect bird. The form of the egg bears not the rudiments of a reſemblance to that of the bird. Inſpecting its contents, we find ſtill leſs reaſon, if poſſible, to look for the reſult which actually takes place. If we ſhould go ſo far, as, from the appearance of order and diſtinction in the diſpoſition of the liquid ſubſtances which we noticed in the egg, to gueſs that it might be deſigned for the abode and nutriment of an animal, (which would be a very bold hypotheſis,) we ſhould expect a tadpole dabbling in the ſlime, much rather than a dry, winged, feathered creature; a compound of parts and properties impoſſible to be uſed in a ſtate of confinement in the egg, and bearing no conceivable relation, either in quality or material, to any thing obſerved in it. From the white of an egg, would any one look for the feather of a goldfinch? or expect from a ſimple uniform mucilage, the moſt complicated of all machines, the moſt diverſified of all collections of ſubſtances? Nor would the proceſs of incubation, for ſome time at leaſt, lead us to ſuſpect the event.—Who that ſaw red ſtreaks, ſhooting in the fine membrane which divides the white from the yolk, would ſuppoſe that theſe were about to become bones and limbs? Who, that eſpied two diſcoloured points firſt making their appearance in the cicatrix, would have had the courage to predict, that theſe points were to grow into the heart and head of a bird? It is difficult to ſtrip the mind of its experience. It is difficult to reſuſcitate ſurpriſe, when familiarity has once laid the ſentiment aſleep. But could we forget all that we know, and which *our* ſparrows never knew, about oviparous generation; could we diveſt ourſelves of every information, but what we derived from reaſoning upon the appearances or quality diſcovered in the objects preſented to us, I am convinced that Harlequin coming out of an egg upon the ſtage, is not more aſtoniſhing to a child, than the hatching of a chicken both would be, and ought to be, to a philoſopher.

But admit the ſparrow by ſome means to know, that within that egg was concealed the principle of a future bird, from what chymiſt was ſhe to learn, that *warmth* was neceſſary to bring it to maturity, or that the degree of warmth, imparted by the temperature of her own body, was the degree required?

To ſuppoſe, therefore, that the female bird acts in this proceſs from a ſagacity and reaſon of her own, is to ſuppoſe her to arrive at concluſions, which there are no premiſes to juſtify. If our ſparrow, ſitting upon her eggs, expect young ſparrows to come out of them, ſhe forms, I will venture to ſay, a wild and extravagant expectation, in oppoſition to preſent appearances, and to probability. She muſt have penetrated into the order of nature, further than any faculties of ours will carry us: and it hath been well obſerved, that this deep ſagacity, if it be ſagacity, ſubſiſts in conjunction with great ſtupidity, even in relation to the ſame ſubject. "A chymical operation," ſays Addiſon, "could not be followed with greater art or diligence, than is ſeen in hatching a chicken: yet is the proceſs carried on without the leaſt glimmering of thought or common ſenſe. The hen will miſtake a piece of chalk for an egg; is inſenſible of the increaſe or diminution of their number; does not diſtinguiſh between her own, and thoſe of another ſpecies; is frightened when her ſuppoſititious breed of ducklings take the water."

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

Of young birds taken in their neſts, a few ſpecies breed, when kept in cages; and they which do ſo, build their neſts nearly in the ſame manner as in the wild ſtate, and ſit upon their eggs. This is ſufficient to prove an inſtinct, without having recourſe to experiments upon birds, hatched by artificial heat, and deprived, from their birth, of all communication with their ſpecies: for we can hardly bring ourſelves to believe, that the parent bird informed her unfledged pupil of the hiſtory of her geſtation, her timely preparation of a neſt, her excluſion of the eggs, her long incubation, and of the joyful eruption at laſt of her expected offspring: all which the bird in the cage muſt have learnt in her infancy, if we reſolve her conduct into *inſtitution.*

Unleſs we will rather ſuppoſe that ſhe remembers her own eſcape from the egg; had attentively obſerved 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 fees a brood of callow birds in their neft, 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 neft before the laying of the egg." This fhe could not gain from obfervation in her infancy.

It is remarkable alfo, that the hen fits upon eggs, which fhe has laid without any communication with the male ; and which are therefore neceffarily unfruitful. That fecret fhe is not let into. Yet, if incubation had been a fubject of inftruction or of tradition, it fhould feem that this diftinction would have formed part of the leffon : whereas the inftinct of nature is calculated for a ftate of nature ; the exception, here alluded to, taking place, chiefly, if not folely, amongft domefticated fowls, in which nature is forced out of her courfe.

There is another cafe of oviparous œconomy, which is ftill lefs likely to be the effect of education, than it is even in birds, namely, that of *moths* and *butterflies*, which depofit their eggs in the precife fubftance, that of a cabbage for example, from which, not the butterfly herfelf, but the caterpillar which is to iffue from her egg, draws its appropriate food. The butterfly cannot tafte the cabbage. Cabbage is no food for her : yet in the cabbage, not by chance, but ftudioufly and electively, fhe lays her egg. There are, amongft 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 converfe. This choice, as appears to me, cannot in the butterfly proceed from inftruction. She had no teacher in her caterpillar ftate She never knew her parent. I do not fee, therefore, how knowledge acquired by experience, if it ever were fuch, could be tranfmitted 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 ſhews 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 phænomena, that which ſets the whole at work, the [*ſtorgē,*] the parental affection, which I contend to be inexplicable upon any other hypotheſis than that of inſtinct.

For we ſhall, hardly, I imagine, in brutes, refer their conduct towards their offspring to a ſenſe of duty, or decency, a care of reputation, a compliance with public manners, with public laws, or with rules of life built upon a long experience of their utility. And all attempts to account for the parental affection from aſſociation, I think, fail. With what is it aſſociated ? Moſt immediately with the throes of parturition, that is, 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 elſe, which proceeds from the body, is caſt away and rejected.

In birds, is it the egg which the hen loves? or is it the expectation which ſhe cheriſhes of a future progeny, that keeps her upon her neſt? What cauſe has ſhe to expect delight from her progeny? Can any rational anſwer be given to the queſtion, why, prior to experience, the brooding hen ſhould look for pleaſure from her chickens? It does not, I think, appear, that the cuckoo ever knows her young: yet, in her way, ſhe is careful in making proviſion for them, as any other bird. She does not leave her egg in every hole.

The ſalmon ſuffers no ſurmountable obſtacle to oppoſe her progreſs up the ſtream of freſh rivers. And what does ſhe do there? She ſheds a ſpawn, which ſhe immediately quits, in order to return to the ſea; and this iſſue of her body ſhe never afterwards recognizes in any ſhape whatever. Where ſhall we find a motive for her efforts, and her perſeverance? Shall we ſeek it in argumentation, or in inſtinct? The violet crab of Jamaica performs a fatiguing march, of ſome months continuance, from the mountains to the ſea ſide. When ſhe reaches the coaſt, ſhe caſts her ſpawn into the open ſea; and ſets out upon her return home.

Moths and butterflies, as hath already been obſerved, ſeek out for their eggs, thoſe preciſe ſituations and ſubſtances, in which the offspring caterpillar will find its appropriate food. That dear caterpillar the parent butterfly muſt never ſee. There are no experiments to prove that ſhe would retain any knowledge of it, if ſhe did. How ſhall we account for her conduct? I do not mean for her art and judgment in ſelecting and ſecuring a maintenance for her young, but for the impulſe upon which ſhe acts. What ſhould induce her to exert any art, or judgment, or choice, about the matter? The undisclosed grub, the animal, which she 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 the general preservation of the species; a kind of patriotism; a solicitude lest the butterfly race should cease from the creation.

Lastly; the principle of association will not explain the discontinuance of the affection when the young animal is grown up. Association, operating in its usual way, would rather produce a contrary effect.—The object 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 labour 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 ac-

* Goldsmith's Nat. Hist. vol. iv. p. 244.

cording 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, which she scoops out in the trunks of soft or decayed trees, and in which 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 Brasils, which man seldom frequents, the same bird hangs her nest to 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 alledged, 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 the 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 a theory, which resolves instinct into sensation; which asserts, that what appears to have a view and relation to the future, is the result 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 the pressure of the smooth convex surface of the shells against the abdomen, or by the relief, which the mild temperature of the egg may afford to the heat of the lower 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, in so many instances, the teat of its dam, is explained from the sense of smell, which is attracted by the odour of the 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 the teat of the dam is not explained by simply referring it to the sense of smell. What made the scent of the 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 fubftance, from which the fcent iffued, was the material of its food. It had never tafted milk before its birth. None of the animals, which are not defigned for that nourifhment, ever offer to fuck, or to feek out any fuch food. What is the conclufion, but that the fugefcent parts of animals are fitted for their ufe, and the knowledge of that ufe put into them?

We affert, fecondly, that, even as to the cafes in which the hypothefis has the faireft claim to confideration, it does not at all leffen the force of the argument for intention and defign. The doctrine of inftincts, is that of appetencies, fuperadded to the conftitution of an animal, for the effectuating of a purpofe beneficial to the fpecies. The above ftated folution would derive thefe appetencies from organization; but then this organization is not lefs fpecifically, not lefs precifely, and, therefore, not lefs evidently adapted to the fame ends, than the appetencies themfelves would be upon the old hypothefis. In this way of confidering the fubject, fenfation fupplies the place of forefight: 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 ftate of her abdomen, fhe experiences from the preffure of round fmooth furfaces, or from the application of a temperate warmth. How comes this extraordinary heat or itching, or call it what you will, which you fuppofe to be the caufe of the bird's inclination, to be felt, juft at the time when the inclination itfelf is wanted; when it tallies fo exactly with the internal conftitution of the egg, and with the help which that conftitution requires in order to bring it to maturity? In my opinion, this folution, if it be accepted as to the fact, ought to increafe, rather than otherwife, our admiration of the contrivance. A gardener lighting up his ſtoves, juſt when he wants to force his fruit, and when his trees require the heat, gives not a more certain evidence of deſign. So again; when a male and female ſparrow come together, they do not meet to confer upon the expediency of perpetuating their ſpecies. As an abſtract propoſition, they care not the value of a barley corn whether the ſpecies be perpetuated, or not. They follow their ſenſations; and all thoſe conſequences enſue, which the wiſeſt counſels could have dictated, which the moſt ſolicitous care of futurity, which the moſt anxious concern for the ſparrow world, could have produced. But how do theſe conſequences enſue? The ſenſations, and the conſtitution upon which they depend, are as manifeſtly directed to the purpoſe which we ſee fulfilled by them; and the train of intermediate effects, as manifeſtly laid and planned with a view to that purpoſe, that is to ſay, deſign is as completely evinced by the phænomena, as it would be, even if we ſuppoſe the operations to begin, or to be carried on, from what ſome will allow to be alone properly called inſtincts, that is, from deſires directed to a future end, and having no accompliſhment or gratification diſtinct from the attainment of that end.

In a word; I ſhould ſay to the patrons of this opinion, Be it ſo: be it, that thoſe actions of animals which we refer to inſtinct, are not gone about with any view to their conſequences, but that they are attended in the animal with a preſent gratification, and are purſued for the ſake of that gratification alone; what does all this prove, but that the *proſpection*, which muſt be ſomewhere, is not in the animal, but in the Creator?

In treating of the parental affection in brutes, our buſineſs lies rather with the origin of the principle, than with the effects and expreſſions of it. Writers recount theſe with pleaſure and admiration. The conduct of many kinds of animals towards their young, has escaped no observer, no historian, of nature. "How will they caress them," says Derham, "with their affectionate notes; lull and quiet them with their tender parental voice; put food into their mouths; cherish, and keep them warm; teach them to pick, and eat, and gather food for themselves; and, in a word, perform the part of so many nurses, deputed by the sovereign Lord and preserver of the world, to help such young and shiftless creatures?" Neither ought it, under this head, to be forgotten, how much the instinct *costs* the animal which feels it; how much a bird, for example, gives up, by sitting upon her nest; how repugnant it is to her organization, her habits, and her pleasures. An animal, formed for liberty, submits to confinement, in the very season when every thing invites her abroad: what is more; an animal delighting in motion, made for motion, all whose motions are so easy and so free, hardly a moment, at other times, at rest, is, for many hours of many days together, fixed to her nest, as close as if her limbs were tied down by pins and wires. For my part, I never see a bird in that situation, but I recognize an invisible hand, detaining the contented prisoner from her fields and groves, for a purpose, as the event proves, the most worthy of the sacrifice, the most important, the most beneficial.

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

One observation more, and I will dismiss the subject. The *pairing* of birds, and the *non-pairing* of beasts, forms a distinction, between the two classes, which shews that the conjugal instinct is modified with a reference to utility founded in the condition of the offspring. In quadrupeds, the young animal draws its nutriment from the body of the dam. The male parent neither does, nor can, contribute any part to its sustentation. In the feathered race, the young bird is supplied by an importation of food, to procure and bring home which, in a sufficient quantity for the demand of a numerous brood, requires the industry of both parents. In this difference we see a reason, for the vagrant instinct of the quadruped, and for the faithful love of the feathered mate.

CHAPTER XIX.

OF INSECTS.

We are not writing a system of natural history; therefore, we have not attended to the classes, into which the subjects of that science are distributed. What we had to observe concerning different species of animals, fell easily, for the most part, within the divisions, which the course of our argument led us to adopt. There remain, however, some remarks upon the *insect* tribe, which could not properly be introduced under any of these heads; and which therefore we have collected into a chapter by themselves.

The structure, and the use of the parts, of insects, are less understood than that of quadrupeds and birds, not only by reason of their minuteness, or the minuteness of their parts, (for that minuteness we can, in some measure, follow with glasses) but also, by reason of the remoteness of their manners and modes of life from those of larger animals. For instance; Insects, under all their varieties of form, are endowed with *antennæ*, which is the name given to those long feelers that rise from each side of the head; but to what common use or want of the insect kind, a provision so universal is subservient, has not yet been ascertained; and it has not been afcertained, becaufe it admits not of a clear, or very probable comparifon, with any organs which we poffefs ourfelves, or with the organs of animals which refemble ourfelves in their functions and faculties, or with which we are better acquainted than we are with infects. We want a ground of analogy. This difficulty ftands in our way as to fome particulars in the infect conftitution which we might wifh to be acquainted with. Neverthelefs, there are many contrivances in the bodies of infects, neither dubious in their ufe, nor obfcure in their ftructure, and moft properly mechanical. Thefe form parts of *our* argument.

I. The *elytra*, or fcaly wings of the genus of fcarabæus or beetle, furnifh an inftance of this kind. The true wing of the animal is a light tranfparent membrane, finer than the fineft gauze, and not unlike it. It is alfo, when expanded, in proportion to the fize of the animal, very large. In order to protect this delicate ftructure, and, perhaps, alfo to preferve it in a due ftate of fupplenefs and humidity, a ftrong, hard, cafe is given to it, in the fhape of the horny wing which we call the elytron. When the animal is at reft, the gauze wings lie folded up under this impenetrable fhield. When the beetle prepares for flying, he raifes the integument, and fpreads out his thin membrane to the air. And it cannot be obferved without admiration, what a tiffue of cordage, i. e. of mufcular tendons, muft run, in various and complicated, but determinate directions, along this fine furface, in order to enable the animal, either to gather it up into a certain precife form, whenever it defires to place its wings under the fhelter which nature hath given to them; or to expand again their folds, when wanted for action.

In fome infects, the elytra cover the whole body; in others, half; in others, only a fmall part of it; but in all they completely hide and cover the true wings.

Alſo, many or moſt of the beetle ſpecies lodge in holes in the earth, environed by hard, rough, ſubſtances, and have frequently to ſqueeze their way through narrow paſſages; in which ſituation, wings ſo tender, and ſo large, could ſcarcely have eſcaped injury, without both a firm covering to defend them, and the capacity of collecting themſelves up under its protection.

II. Another contrivance, equally mechanical, and equally clear, is the *awl* or borer fixed at the tails of various ſpecies of flies; and with which they pierce, in ſome caſes, plants; in others, wood; in others, the ſkin and fleſh of animals; in others, the coat of the chryſalis of inſects of a different ſpecies from their own; and in others, even lime, mortar, and ſtone. I need not add, that having pierced the ſubſtance, they depoſit their eggs in the hole. The deſcriptions, which naturaliſts give of this organ, are ſuch as the following. It is a ſharp-pointed inſtrument, which, in its inactive ſtate, lies concealed in the extremity of the abdomen, and which the animal draws out at pleaſure, for the purpoſe of making a puncture in the leaves, ſtem, or bark of the particular plant, which is ſuited to the nouriſhment of its young. In a ſheath, which divides and opens whenever the organ is uſed, there is incloſed a compact, ſolid, dentated ſtem, along which runs a *gutter* or *groove*, by which groove, after the penetration is effected, the egg, aſſiſted, in ſome caſes, by a periſtaltic motion, paſſes to its deſtined lodgment. In the œſtrum or gadfly, the wimble *draws out* like the pieces of a ſpy-glaſs; the laſt piece is armed with three hooks, and is able to bore through the hide of an ox. Can any thing more be neceſſary to diſplay the mechaniſm, than to relate the fact?

III. The *ſtings* of inſects, though for a different purpoſe, are, in their ſtructure, not unlike the piercer. The sharpness to which the point in all of them is wrought: the temper and firmness of the substance of which it is composed; the strength of the muscles by which it is darted out, compared with the smallness and weakness of the insect, and with the soft or friable texture of the rest of the body; are properties of the sting to be noticed, and not a little to be admired. The sting of a *bee* will pierce through a goatskin glove. It penetrates the human skin more readily than the finest point of a needle. The *action* of the sting affords an example of the union of chymistry and mechanism, such as, if it be not a proof of contrivance, nothing is. First, as to the chymistry; how highly concentrated must be the *venom*, which, in so small a quantity, can produce such powerful effects? And in the bee we may observe, that this venom is made from *honey*, the only food of the insect, but the last material from which I should have expected, that an exalted poison could, by any process or digestion whatsoever, have been prepared. In the next place, with respect to the mechanism, the sting is not a simple, but a compound instrument. The visible sting, though drawn to a point exquisitely sharp, is in strictness only a sheath; for, near to the extremity, may be perceived by the microscope two minute orifices, from which orifices, in the act of stinging, and, as it should seem, after the main sting has buried itself in the flesh, are launched out two subtile rays, which may be called the true or proper stings, as being those through which the poison is infused into the puncture already made by the exterior sting. I have said that chymistry and mechanism are here *united*: by which observation I meant, that all this machinery would have been useless, telum imbelle, if a supply of poison, intense in quality, in proportion to the smallness of the drop, had not been furnished to it by the chymical elaboration which was carried on in the insect's body: and that, on the other hand, the poiſon, the reſult of this proceſs, could not have attained its effect, or reached its enemy, if, when it was collected at the extremity of the abdomen, it had not found there a machinery, fitted to conduct it to the external ſituations in which it was to operate, viz. an awl to bore a hole, and a ſyringe to inject the fluid. Yet theſe attributes, though combined in their action, are independent in their origin. The venom does not breed the ſting; nor does the ſting concoct the venom.

IV. The *proboſcis*, with which many inſects are endowed, comes next in order to be conſidered. It is a tube attached to the head of the animal. In the bee, it is compoſed of two pieces, connected by a joint: for, if it were conſtantly extended, it would be too much expoſed to accidental injuries: therefore, in its indolent ſtate, it is doubled up by means of the joint, and in that poſition lies ſecure under a ſcaly penthouſe. In many ſpecies of the butterfly, the proboſcis, when not in uſe, is coiled up like a watch-ſpring. In the ſame bee, the proboſcis ſerves the office of the mouth, the inſect having no other: and how much better adapted it is, than a mouth would be, for the collecting of the proper nouriſhment of the animal, is ſufficiently evident. The food of the bee is the nectar of flowers; a drop of ſyrup, lodged deep in the bottom of the corollæ, in the receſſes of the petals, or down the neck of a monopetalous glove. Into theſe cells the bee thruſts its long narrow pump, through the cavity of which it ſucks up this precious fluid, inacceſſible to every other approach. The ringlets of which the proboſcis of the bee is compoſed, the muſcles by which it is extended and contracted, form ſo many microſcopical wonders. The agility alſo, with which it is moved, can hardly fail to excite admiration. But it is enough for our purpoſe to obſerve in general, the ſuitableneſs of the ſtructure to the uſe, of the means to the end, and eſpecially the wiſdom, by which nature has departed from its moſt general analogy (for animals being furniſhed with mouths is ſuch) when the purpoſe could be better anſwered by the deviation.

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

V. The *metamorphoſis* of inſects from grubs into moths and flies, is an aſtoniſhing proceſs. A hairy caterpillar is transformed into a butterfly. Obſerve the change. We have four beautiful wings, where there were none before; a tubular proboſcis, in the place of a mouth with jaws and teeth; ſix long legs, inſtead of fourteen feet. In another caſe, we ſee a white, ſmooth, ſoft worm, turned into a black, hard, cruſtaceous beetle, with gauze wings. Theſe, as I ſaid, are aſtoniſhing proceſſes, and muſt require, as it ſhould ſeem, a proportionably artificial apparatus. The hypotheſis which appears to me moſt probable is, that, in the grub, there exiſt at the ſame time, three animals, one within another, all nouriſhed by the ſame digeſtion, and by a communicating circulation; but in different ſtages of maturity. The lateſt diſcoveries, made by naturaliſts, ſeem to favour this ſuppoſition. The inſect already equipped with wings, is deſcried under the membranes both of the worm and nymph. In ſome ſpecies, the proboſcis, the antennæ, the limbs and wings of the fly, have been obſerved to be folded up within the body of the caterpillar; and with ſuch nicety, as to occupy a ſmall ſpace only under the two firſt rings. This being ſo, the outermoſt animal, which beſide its own proper character, ſerves as an integument to the other two, being the furtheſt advanced, dies, as we ſuppoſe, and drops off firſt. The ſecond, the pupa or chryſalis, then offers itſelf to obſervation. This alſo, in its turn, dies; its dead and brittle huſk falls to pieces, and makes way for the appearance of the fly or moth. Now, if this be the caſe, or indeed whatever explication be adopted, we have a proſpective contrivance of the moſt curious kind: we have organizations *three deep*, yet a vaſcular ſyſtem, which ſupplies nutrition, growth, and life, to all of them together.

VI. Almoſt all inſects are oviparous. Nature keeps her butterflies, moths and caterpillars, locked up during the winter in their egg ſtate; and we have to admire the various devices, to which, if we may ſo ſpeak, the ſame nature hath reſorted, for the *ſecurity* of the egg. Many inſects incloſe their eggs in a ſilken web; others cover them with a coat of hair, torn from their own bodies; ſome glue them together; and others, like the moth of the ſilk-worm, glue them to the leaves upon which they are depoſited, that they may not be ſhaken off by the wind, or waſhed away by rain: ſome again make inciſions into leaves, and hide an egg in each inciſion; whilſt ſome envelope their eggs with a ſoft ſubſtance, which forms the firſt aliment of the young animal; and ſome again make a hole in the earth, and, having ſtored it with a quantity of proper food, depoſit their egg in it. In all which we are to obſerve, that the expedient depends, not ſo much upon the addreſs of the animal, as upon the phyſical reſources of his conſtitution.

The art alſo with which the young inſect is *coiled up* in the egg, preſents, where it can be examined, a ſubject 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 ſilk-worm 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 ſilk-worm has wrapped itſelf up: in the ſpider the web is formed of 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 faſtened to a point, the inſect, by turning round its body, or by receding from that point, draws out the thread through the holes above deſcribed, by an operation, as hath been obſerved, exactly ſimilar to the drawing of wire. The thread, like the wire, is formed by the hole through which it paſſes. In one reſpect there is a difference. The wire is the metal unaltered, except in figure. In the animal process, the nature of the substance is somewhat changed, as well as the form: for, as it exists within the insect, it is a soft, clammy, gum or glue. The thread acquires, it is probable, its firmness and tenacity from the action of the air upon its surface, in the moment of exposure: and a thread so fine is almost all surface. This property, however, of the paste, is part of the contrivance.

The mechanism itself consists of the bags, or reservoirs, into which the glue is collected, and of the external holes communicating with these bags: and the action of the machine is seen, in the forming of a thread, as wire is formed, by forcing the material already prepared, through holes of proper dimensions. The secretion is an act too subtle for our discernment, except as we perceive it by the produce. But one thing answers to another: the secretory glands to the quality and consistence required in the secreted substance; the bag to its reception. The outlets and orifices are constructed, not merely for relieving the reservoirs of their burthen, but for manufacturing the contents into a form and texture, of great external use, or rather indeed of future necessity, to the life and functions 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 the 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 neading 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, moreover, wanting the honey when it could not be procured at all, it was further endued with the no leſs neceſſary faculty of conſtucting repoſitories for its preſervation? which faculty, it is evident, muſt depend, primarily, upon the capacity of providing ſuitable materials. Two diſtinct functions go to make up the ability. Firſt, the power in the bee, with reſpect to wax, of loading the farina of flowers upon its thighs: microſcopic obſervers ſpeak of the ſpoon-ſhaped appendages, with which the thighs of bees are beſet for this very purpoſe: but inaſmuch as the art and will of the bee may be ſuppoſed to be concerned in this operation, there is, ſecondly, that which doth not reſt in art or will, a digeſtive faculty which converts the looſe powder into a ſtiff ſubſtance. This is a juſt account of the honey and the honey comb: and this account, through every part, carries a creative intelligence along with it.

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

III. Our buſineſs is with mechaniſm. In the *panorpa* tribe of inſects, there is a forceps in the tail of the male inſect, with which he catches and holds the female. Are a pair of pinches more mechanical, than this proviſion, in their ſtructure? or is any ſtructure more clear and certain in its deſign?

IV. St. Pierre tells us,* that in a fly with ſix feet (I do not remember that he deſcribes the ſpecies) the pair next the head, and the pair next the tail, have bruſhes at their extremities, with which the fly dreſſes, as there may be occaſion, the anterior or the poſterior part of its body; but that the middle pair have no ſuch bruſhes, the ſituation of theſe legs not admitting of the bruſhes, if they were there, being converted to the ſame uſe. This is a very exact mechanical diſtinction.

V. If the reader, looking to our diſtributions of ſcience, wiſh to contemplate the chymiſtry, as well as the mechaniſm of nature, the inſect creation will afford him an example. I refer to the light in the tail of a *glow-worm*. Two points ſeem to be agreed upon by naturaliſts concerning it: firſt, that it is phoſphoric; ſecondly, that its uſe is to attract the male inſect. The only thing to be enquired after, is the ſingularity, if any ſuch there be, in the natural hiſtory of this animal, which ſhould render a proviſion of this kind more neceſſary for *it*, than for other inſects. That ſingularity ſeems to be the difference, which ſubſiſts between the male and the female; which difference is greater than what we find in any other ſpecies of animal whatever. The glow-worm is a female *caterpillar;* the male of which is a *fly;* lively, comparatively ſmall, diſſimilar to the female in appearance, probably alſo as diſtinguiſhed from her in hab-

* Vol. i. p. 342.

its, purſuits, and manners, as he is unlike in form and external conſtitution. Here then is the adverſity of the caſe. The caterpillar cannot meet her companion in the air. The winged rover diſdains the ground. They might never therefore be brought together, did not this radiant torch direct the volatile mate to his ſedentary female.

In this example we alſo ſee the reſources of art anticipated. One grand operation of chymiſtry is the making of phoſphorus; and it was thought an ingenious device, to make phoſphoric matches ſupply the place of lighted tapers. Now this very thing is done in the body of the glow-worm. The phoſphorus is not only made, but kindled; and cauſed to emit a ſteady and genial beam, for the purpoſe which is here ſtated, and which I believe to be the true one.

VI. Nor is the laſt the only inſtance that entomology affords, in which our diſcoveries, or rather our projects, turn out to be imitations of nature. Some years ago, a plan was ſuggeſted, of producing propulſion by reaction in this way. By the force of a ſteam engine, a ſteam of water was to be ſhot out of the ſtern of a boat; the impulſe of which ſtream upon the water in the river, was to puſh the boat itſelf forward: it is, in truth, the principle by which ſky-rockets aſcend in the air. Of the uſe or the practicability of the plan, I am not ſpeaking; nor is it my concern to praiſe its ingenuity; but it is certainly a contrivance. Now, if naturaliſts are to be believed, it is exactly the device, which nature has made uſe of, for the motion of ſome ſpecies of aquatic inſects. The larva of the *dragon fly*, according to Adams, ſwims by ejecting water from its tail; is driven forward by the reaction of water in the pool upon the current iſſuing in a direction backward from its body.

VII. Again; Europe has lately been ſurpriſed by the elevation of bodies in the air by means of a balloon. The discovery consisted in finding out a manageable substance, which was, bulk for bulk, lighter than air; and the application of the discovery was, to make a body composed of this substance bear up, along with its own weight, some heavier body which was attached to it. This expedient, so new to us, proves to be no other than what the author of nature has employed in the *gossamir spider*. We frequently see this spider's thread floating in the air, and extended from hedge to hedge, across a road or brook of four or five yards width. The animal which forms the thread, has no wings wherewith to fly from one extremity to the other of this line; nor muscles to enable it to spring or dart to so great a distance. Yet its creator hath laid for it a path in the atmosphere; and after this manner. Though the animal itself be heavier than air, the thread which it spins from its bowels is specifically lighter. This is its *balloon*. The spider left to itself would drop to the ground; but, being tied to its thread, both are supported. We have here a very peculiar provision: and to a contemplative eye it is a gratifying spectalce, to see this insect wafted on her thread, sustained by a levity not her own, and traversing regions, which, if we examined only the body of the animal, might seem to have been forbidden to its nature.

I MUST now crave the reader's permission to introduce into this place, for want of a better, an observation or two upon the tribe of animals, whether belonging to land or water, which are covered by *shells*.

I. The *shells* of *snails* are a wonderful, a mechanical, and, if one might so speak, concerning the works of nature, an original contrivance. Other animals have their proper retreats, their hybernacula also or winter quarters, but the snail carries these about with him. He travels with his tent; and this tent, though, as was neceſſary, both light and thin, is completely impervious either to moiſture or air. The young ſnail comes out of its egg with the ſhell upon its back; and the gradual enlargement which the ſhell receives, is derived from the ſlime excreted by the animal's ſkin. Now the aptneſs of this excretion to the purpoſe, its property of hardening into a ſhell, and the action, whatever it be, of the animal, whereby it avails itſelf of its gift, and of the conſtitution of its glands, (to ſay nothing of the work being commenced before the animal is born,) are things, which can, with no probability, be referred to any other cauſe than to expreſs deſign; and that not on the part of the animal alone, in which deſign, though it might build the houſe, could not have ſupplied the material. The will of the animal could not determine the quality of the excretion. Add to which, that the ſheil of a ſnail, with its pillar and convolution, is a very artificial fabric; whilſt a ſnail, as it ſhould ſeem, is the moſt numb and unprovided of all artificers. In the midſt of variety, there is likewiſe a regularity, which would 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 fifh. 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, fetting in water, and into a cretaceous fubftance, firm and hard. This property is much more extraordinary, and, chymically fpeaking, more fpecific, than that of hardening in the air; which may be reckoned a kind of exficcation, like the drying of clay into bricks.

III. In the *bivalve* order of fhell fifh, cockles, mufcles, oyfters, &c. what contrivance can be fo fimple or fo clear, as the infertion, at the back, of a tough, tendinous, fubftance, that becomes, at once, the ligament which binds the two fhells together, and the *hinge* upon which they open and fhut?

IV. The fhell of a lobfter's tail, in its articulations and overlappings, reprefents 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 lobfter's fhell. The fame end is to be anfwered by both: the fame properties, therefore, are required in both, namely, hardnefs and flexibility, a covering which may guard the part without obftructing its motion. For this double purpofe, the art of man, exprefsly exercifed upon the fubject, has not been able to devife any thing better than what nature prefents to his obfervation. Is not this therefore mechanifm, which the mechanic, having a fimilar purpofe in view, adopts? Is the ftructure of a coat of mail to be referred to art? Is the fame ftructure of a lobfter, conducing to the fame ufe, to be referred to any thing lefs than art?

Some, who may acknowledge the imitation, and affent to the inference which we may draw from it, in the inftance before us, may be difpofed, poffibly, to afk, why fuch imitations are not more frequent than they are, if it be true, as we alledge, that the fame principle of intelligence, defign, 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 ſeldomer 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 of a lobſter's ſhell compared with a coat of mail, theſe difficulties ſtand leſs in the way, than in almoſt any other that can be aſſigned; and the conſequence is, as we have ſeen, that art gladly borrows from nature her contrivance, and imitates it cloſely.

But to return to inſects. I think it is in this claſs of animals, above all others, eſpecially when we take in the multitude of ſpecies which the microſcope diſcovers, that we are ſtruck with what Cicero has called "the *inſatiable* variety of nature." There are ſaid to be ſix thouſand ſpecies of flies; ſeven hundred and ſixty butterflies: each different from all the reſt, (St. Pierre.) The ſame writer tells us from his own obſervation, that thirty-ſeven ſpecies of winged inſects, with diſtinctions well expreſſed, viſited a ſingle ſtrawberry plant in the courſe of three weeks.* *Ray* obſerved, within the compaſs of a mile or two of his own houſe, two hundred kinds of butterflies, nocturnal and diurnal. He likewiſe aſſerts, but, I think, without any grounds of exact computation, that the number of ſpecies of inſects, reckoning all ſorts of them, may not be ſhort of ten thouſand.† And in this vaſt variety of animal forms, (for the obſervation

* Vol. i. p. 3. † Wiſ. of God, p. 23.

is not confined to insects, though more applicable perhaps to them than to any other class,) we are sometimes led to take notice of the different methods, or rather of the studiously diversified methods, by which one and the same purpose is attained. In the article of breathing, for example, which was to be provided for in some way or other, beside the ordinary varieties of lungs, gills, and breathing-holes, (for insects in general respire, not by the mouth, but through holes in the sides,) the nymphæ of gnats have an apparatus to raise their *backs* to the top of the water, and so take breath. The hydrocanthari do the like by thrusting their *tails* out of the water.* The maggot of the eruca labra has a long tail, one part sheathed within another, (but which it can draw out at pleasure,) with a starry tuft at the end, by which *tuft*, when expanded upon the surface, the insect both supports itself in the water, and draws in the air which is necessary. In the article of natural clothing, we have the skins of animals invested with scales, hair, feathers, mucus, froth; or itself turned into a shell or crust: in the no less necessary article of offence and defence, we have teeth, talons, beaks, horns, stings, prickles, with (the most singular expedient for the same purpose) the power of giving the electric shock, and, as is credibly related of some animals, of driving away their pursuers by an intolerable fœtor, or of blackening the water through which they are pursued. The consideration of these appearances might induce us to believe, that *variety* itself, distinct from every other reason, was a motive in the mind of the Creator, or with the agents of his will.

To this great variety in organized life, the Deity has given, or perhaps there arises out of it, a corresponding variety of animal *appetites*. For the final

* Derham, p. 7.

caufe of this we have not far to feek. Did all animals covet the fame element, retreat, or food, it is evident how much fewer could be fupplied and accommodated, than what at prefent live conveniently together, and find a plentiful fubfiftence. What one nature rejects, another delights in. Food, which is naufeous to one tribe of animals, becomes, by that very property which makes it naufeous, an alluring dainty to another tribe. Carrion is a treat to dogs, ravens, vultures, fifh. The exhalations of corrupted fubftances attract flies by crowds. Maggots revel in putrefaction.

CHAPTER XX.

OF PLANTS.

I THINK a defigned and ftudied mechanifm to be, in general, more evident in animals, than in *plants:* and it is unneceffary to dwell upon a weaker argument, where a ftronger is at hand. There are, however, a few obfervations upon the vegetable kingdom, which lie fo directly in our way, that it would be improper to pafs by them without notice.

The one great intention of nature in the ftructure of plants, feems to be the perfecting of the *feed;* and, what is part of the fame intention, the preferving of it until it be *perfected.* This intention fhews itfelf, in the firft place, by the care which appears to be taken to protect and ripen, by every advantage which can be given to them of fituation in the plant, thofe parts which moft immediately contribute to fructification, viz. the antheræ, the ftamina, and the ftigmata.— Thefe parts are ufually lodged in the centre, the receffes, or the labyrinths of the flower; during their tender and immature ftate, are fhut up in the ftalk, or ſheltered in the bud: as ſoon as they have acquired firmneſs of texture ſufficient to bear expoſure, and are ready to perform the important office which is aſſigned to them, they are diſcloſed to the light and air, by the burſting of the ſtem or the expanſion of the petals: after which they have, in many caſes, by the very form of the flower during its blow, the light and warmth reflected upon them from the concave ſide of the cup. What is called alſo the *ſleep* of plants, is the leaves or petals diſpoſing themſelves in ſuch a manner as to ſhelter the young ſtem, buds, or fruit. They turn up, or they fall down, according as this purpoſe renders either change of poſition requiſite — In the growth of corn, whenever the plant begins to ſhoot, the two upper leaves of the ſtalk join together; embrace the ear; and protect it till the pulp has acquired a certain degree of conſiſtency. In ſome water plants, the flowering and fecundation are carried on *within* the ſtem, which afterwards opens to let looſe the impregnated ſeed.* The *pea* or papilionaceous tribe incloſe the parts of fructification within a beautiful folding of the internal bloſſom, ſometimes called from its ſhape the boat or keel; itſelf alſo protected under a penthouſe formed by the external petals.— This ſtructure is very artificial; and what adds to the value of it though it may diminiſh the curioſity, very general. It has alſo this further advantage (and it is an advantage ſtrictly mechanical) that all the bloſſoms turn their *backs* to the wind, whenever the gale blows ſtrong enough to endanger the delicate parts upon which the ſeed depends. I have obſerved this a hundred times in a field of peas in bloſſom. It is an aptitude which reſults from the figure of the flower, and, as we have ſaid, is ſtrictly mechanical; as much ſo, as the turning of a weather-board or tin cap upon the top of a chimney. Of the *poppy*, and

* Phil. Tranſ. part ii. 1796, p. 502.

of many ſimilar ſpecies of flowers, the head, while it is growing, hangs down, a rigid curvature in the upper part of the ſtem giving to it that poſition; and in that poſition it is impenetrable by rain or moiſture.— When the head has acquired its ſize, and is ready to open, the ſtalk *erects* itſelf, for the purpoſe, as it ſhould ſeem, of preſenting the flower, and, with the flower, the inſtruments of fructification, to the genial influence of the ſun's rays. This always ſtruck me as a curious property; and ſpecifically, as well as originally, provided for in the conſtitution of the plant: for, if the ſtem be only bent by the weight of the head, how comes it to ſtraighten itſelf when the head is the heavieſt? Theſe inſtances ſhew the attention of nature to this principal object, the ſafety and maturation of the parts upon which the ſeed depends.

In *trees*, eſpecially in thoſe which are natives of colder climates, this point is taken up earlier. Many of theſe trees (obſerve in particular the *aſh* and the *horſe cheſnut*) produce the embryos of the leaves and flowers in one year, and bring them to perfection the following. There is a winter therefore to be got over. Now what we are to remark is, how nature has prepared for the trials and ſeverities of that ſeaſon.— Theſe tender embryos, are, in the firſt place, wrapped up with a compactneſs, which no art can imitate: in which ſtate, they compoſe what we call the bud.— This is not all. The bud itſelf is incloſed in ſcales; which ſcales are formed from the remains of paſt leaves, and the rudiments of future ones. Neither is this the whole. In the coldeſt climates a third preſervative is added, by the bud having a *coat* of gum or reſin, which, being congealed, reſiſts the ſtrongeſt froſts. On the approach of warm weather this gum is ſoftened, and ceaſes to be a hindrance to the expanſion of the leaves and flowers. All this care is part of that ſyſtem of proviſions which has for its object and consummation, the production and perfecting of the seeds.

The SEEDS themselves are packed up in a *capsule*, a vessel composed of coats, which, compared with the rest of the flower, are strong and tough. From this vessel projects a tube, through which tube the farina, or some subtle fecundating effluvium that issues from it, is admitted to the seed. And here also occurs a mechanical variety, accommodated to the different circumstances under which the same purpose is to be accomplished. In flowers which are erect, the pistil is shorter than the stamina; and the pollen, shed from the antheræ into the cup of the flower, is catched in its descent by the head of the pistil, called the stigma. But how is this managed when the flowers hang down, (as does the crown imperial, for instance,) and in which position, the farina, in its fall, would be carried from the stigma, and not towards it? The relative length of the parts is now inverted. The pistil in these flowers is usually longer, instead of shorter, than the stamina, that its protruding summit may receive the pollen as it drops to the ground. In some cases, (as in the *nigella*,) where the shafts of the pistils or styles are disproportionably long, they bend down their extremities upon the antheræ, that the necessary approximation may be effected.

But (to pursue this great work in its progress,) the impregnation, to which all this machinery relates, being completed, the other parts of the flower fade and drop off, whilst the *gravid seed-vessel*, on the contrary, proceeds to increase its bulk, always to a great, and in some species, (in the gourd, for example, and melon,) to a surprizing comparative size; assuming in different plants an incalculable variety of forms, but all evidently conducing to the security of the seed. By virtue of this process, so necessary, but so diversified, we have the seed, at length, in stone fruits and nuts, incased in a strong shell, the shell itself inclosed in a pulp or husk, by which the seed within is, or hath been, fed; or, more generally, (as in grapes, oranges, and the numerous kinds of berries) plunged overhead in a glutinous syrup, contained within a skin or bladder: at other times (as in apples and pears) embedded in the heart of a firm fleshy substance; or (as in strawberries) pricked into the surface of a soft pulp.

These and many more varieties exist in what we call *fruits*.* In pulse, and grain, and grasses; in trees, and shrubs, and flowers; the variety of the seed-vessels is incomputable. We have the seeds (as in the pea tribe) regularly disposed in parchment pods, which, though soft and membraneous, completely exclude the wet even in the heaviest rains; the pod also, not seldom (as in the bean) lined with a fine down; at other times (as in the senna) distended like a blown bladder: or we have the seed enveloped in wool (as in the cotton plant,) lodged (as in pines) between the hard and compact scales of a cone; or barricadoed (as in the artichoke and thistle) with spikes and prickles;

* From the conformation of fruits alone, one might be led, even without experience, to suppose, that part of this provision was destined for the utilities of animals. As limited to the plant, the provision itself seems to go beyond its object. The flesh of an apple, the pulp of an orange, the meat of a plumb, the "fatness of the olive," appear to be more than sufficient for the nourishing of the seed or kernel. The event shews, that this redundancy, if it be one, ministers to the support and gratification of animal natures; and when we observe a provision to be more than sufficient for one purpose, yet wanted for another purpose, it is not unfair to conclude that both purposes were contemplated together. It favors this view of the subject to remark, that fruits are not (which they might have been) ready all together, but that they ripen in succession throughout a great part of the year; some in summer; some in autumn; that some require the slow maturation of the winter, and supply the spring: also that the coldest fruits grow in the hottest places. Cucumbers, pine apples, melons, are the natural produce of warm climates, and contribute greatly, by their coolness, to the refreshment of the inhabitants of those countries.

in mushrooms placed under a penthouse; in ferns, within slits in the back part of the leaf; or (which is the most general organization of all) we find them covered by strong, close, tunicles, and attached to the stem according to an order appropriated to each plant, as is seen in the several kinds of grain, and of grasses.

In which enumeration what we have first to notice is, unity of purpose under variety of expedients. Nothing can be more *single* than the design; more *diversified* than the means. Pellicles, shells, pulps, pods, husks, skins, scales armed with thorns, are all employed in prosecuting the same intention. Secondly; we may observe, that, in all these cases, the purpose is fulfilled within a just and *limited* degree. We can perceive, that, if the seeds of plants were more strongly guarded than they are, their greater security would interfere with other uses. Many species of animals would suffer, and many perish, if they could not obtain access to them. The plant would overrun the soil; or the seed be wasted for want of room to sow itself. It is, sometimes, as necessary to destroy particular species of plants, as it is, at other times, to encourage their growth. Here, as in many cases, a balance is to be maintained between opposite uses. The provisions for the preservation of seeds appear to be directed, chiefly against the inconstancy of the elements, or the sweeping destruction of inclement seasons. The depredation of animals, and the injuries of accidental violence, are allowed for in the abundance of the increase. The result is, that, out of the many thousand different plants which cover the earth, not a single species, perhaps, has been lost since the creation.

When nature has perfected her seeds, her next care is to disperse them. The seed cannot answer its purpose, while it remains confined in the capsule. After the seeds therefore are ripened, the pericarpium opens to let them out; and the opening is not like an accidental burſting, but, for the moſt part, is according to a certain rule in each plant. What I have always thought very extraordinary, nuts and ſhells, which we can hardly crack with our teeth, divide and make way for the little tender ſprout which proceeds from the kernel. Handling the nut, I could hardly conceieve how the plantule was ever to get out of it: There are caſes, it is ſaid, in which the ſeed-veſſel, by an elaſtic jerk, at the moment of its exploſion, caſts the ſeed to a diſtance. We all however know, that many ſeeds (thoſe of moſt compoſite flowers, as of the thiſtle, dandelion, &c.) are endowed with what are not improperly called *wings*; that is, downy appendages, by which they are enabled to float in the air, and are carried oftentimes by the wind to great diſtances from the plant which produces them. It is the ſwelling alſo of this downy tuft within the ſeed-veſſel, that ſeems to overcome the reſiſtance of its coats, and to open a paſſage for the ſeed to eſcape.

But the *conſtitution* of ſeeds is ſtill more admirable than either their preſervation or their diſperſion. In the body of the ſeed of every ſpecies of plant, or nearly every one, proviſion is made for two grand purpoſes: firſt, for the ſafety of the *germ*; ſecondly, for the temporary ſupport of the future plant. The ſprout, as folded up in the ſeed, is delicate and brittle, beyond any other ſubſtance. It cannot be touched without being broken. Yet, in beans, peaſe, graſs-ſeeds, grain, fruits, it is ſo fenced on all ſides, ſo ſhut up and protected, that, whilſt the ſeed itſelf is rudely handled, toſſed into ſacks, ſhoveled into heaps, the miniature plant, the ſacred particle, remains unhurt. It is wonderful alſo, how long many kinds of ſeed, by the help of their integuments, and perhaps of their oils, ſtand out againſt decay. A grain of muſtard ſeed has been known to lie in the earth for a hundred years; and, as ſoon as it had acquired a favorable ſituation, to ſhoot as vigorouſly as if juſt gathered from the plant. Then, as to the ſecond point, the temporary ſupport of the future plant, the matter ſtands thus. In grain, and pulſe, and kernels, and pippins, the germ compoſes a very ſmall part of the ſeed. The reſt conſiſts of a nutritious ſubſtance, from which the ſprout draws its aliment for ſome conſiderable time after it is put forth; viz. until the fibres, ſhot out from the other end of the ſeed, are able to imbibe juices from the earth, in a ſufficient quantity for its demand. It is owing to this conſtitution, that we ſee ſeeds ſprout, and the ſprouts make a conſiderable progreſs, without any earth at all. It is an œconomy alſo, in which we remark a cloſe analogy between the ſeeds of plants, and the eggs of animals. The ſame point is provided for, in the ſame manner, in both. In the egg, the reſidence of the living principle, the cicatrix, forms a very minute part of the contents. The white, and the white only, is expended in the formation of the chicken. The yolk, very little altered or diminiſhed, is wrapped up in the abdomen of the young bird, when it quits the ſhell; and ſerves for its nouriſhment, till it have learnt to pick its own food. This perfectly reſembles the firſt nutrition of a plant. In the plant, as well as in the animal, the ſtructure has every character of contrivance belonging to it: In both it breaks the tranſition from prepared to unprepared aliment; in both it is proſpective and compenſatory. In animals which ſuck, this intermediate nouriſhment is ſupplied by a different ſource.

In all ſubjects the moſt common obſervations are the beſt, when it is their truth and ſtrength which have made them common. There are, of this ſort, *two* concerning plants, which it falls within our plan to notice. The *firſt* relates to, what has already been touched upon, their germination. When a grain of corn is caſt into the ground, this is the change which takes place. From one end of the grain iſſues a green ſprout: from the other a number of white fibrous threads. How can this be explained? Why not ſprouts from both ends? Why not fibrous threads from both ends? To what is the difference to be referred, but to deſign; to the different uſes which the parts are thereafter to ſerve; uſes which diſcover themſelves in the ſequel of the proceſs? The ſprout, or plumule, ſtruggles into the air; and becomes the plant, of which, from the firſt, it contained the rudiments: the fibres ſhoot into the earth; and, thereby, both fix the plant to the ground, and collect nouriſhment from the ſoil for its ſupport. Now, what is not a little remarkable, the parts iſſuing from the ſeed take their reſpective directions, into whatever poſition the ſeed itſelf happens to be caſt. If the ſeed be thrown into the wrongeſt poſſible poſition, that is, if the ends point in the ground the reverſe of what they ought to do, every thing, nevertheleſs, goes on right. The ſprout, after being puſhed down a little way, makes a bend and turns upwards; the fibres, on the contrary, after ſhooting at firſt upwards, turn down. Of this extraordinary vegetable fact, an account has lately been attempted to be given. "The plumule, it is ſaid, is ſtimulated by the *air* into action, and elongates itſelf when *it* is thus moſt excited: the radicle is ſtimulated by *moiſture*, and elongates itſelf when *it* is thus moſt excited. Whence one of theſe grows upward in queſt of its adapted object, and the other downward."* Were this account better verified by experiment than it is, it only ſhifts the contrivance. It does not diſprove the contrivance; it only removes it a little further back. Who, to uſe our author's own language, "adapted the ob-

* Darwin's Phytologia, p. 144.

jects?" 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; his 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 its 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 joint, 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 with 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 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 under a treatment by which other plants are deſtroyed. The more their leaves are conſumed, the more their roots increaſe. The more they are trampled upon, the thicker they grow. Many of the ſeemingly dry and dead leaves of graſſes revive, and renew their verdure in the ſpring. In lofty mountains, where the ſummer heats are not ſufficient to ripen the ſeeds, graſſes abound, which are viviparous, and conſequently able to propagate themſelves without ſeed. It is an obſervation likewiſe which has often been made, that herbivorous animals attach themſelves to the leaves of graſſes; and, if at liberty in their paſtures to range and chooſe, leave untouched the ſtraws which ſupport the flowers.*

The general properties of vegetable nature, or properties common to large portions of that kingdom, are almoſt all which the compaſs of our argument allows to bring forward. It is impoſſible to follow plants into their ſeveral ſpecies. We may be allowed, however to ſingle out three or four of theſe ſpecies as worthy of a particular notice, either by ſome ſingular mechaniſm, or by ſome peculiar proviſion, or by both.

I. In Dr. Darwin's Botanic Garden, line 395, note, is the following account of the *vallisneria*, as it has been obſerved in the river Rhone. "They have roots at the bottom of the Rhone. The flowers of the *female plant* float on the ſurface of the water, and are furniſhed with an *elaſtic, ſpiral, ſtalk*, which extends or contracts as the water riſes or falls: this riſe or fall, from 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. Arrang. vol. ii. p 209. ed. 3. "The *cuſcuta europæa* is a paraſitical plant. The ſeed opens, and puts

* With. Bot. Arr. vol. i. p. 28. ed. 2d.

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 earth. Here therefore might seem to be a mortal defect in their constitution. Let us examine how this defect is made up to them. The seeds are endued with an adhesive quality so tenacious, that, if they be rubbed upon the smooth bark of almost any tree, they will stick to it. And then what follows? Roots springing from their seeds, insinuate their fibres into the woody substance of the tree; and the event is, that a misseltoe plant is produced the next winter.* Of no other plant do the roots refuse to shoot in the ground; of no other plant do the seeds possess this adhesive, generative, quality, when applied to the bark of trees.

IV. Another instance of the *compensatory* system is in the autumnal crocus or meadow saffron, (*cholcicum autumnale.*) I have pitied this poor plant a thousand times. Its blossom rises out of the ground in the most forlorn condition possible; without a sheath, a fence, a calynx, or even a leaf to protect it; and that, not in the spring, not to be visited by summer suns, but under all the disadvantages of the declining year. When we come however to look more

* Ib. p. 203.

closely into the structure of this plant, we find that, instead of its being neglected, nature has gone out of her course to provide for its security, and to make up to it for all its defects. The seed-vessel, which in other plants is situated within the cup of the flower, or just beneath it, in this plant lies buried ten or twelve inches under ground within the bulbous root. The tube of the flower, which is seldom more than a few tenths of an inch long, in this plant extends down to the root. The styles always reach the seed-vessel; but it is in this, by an elongation unknown to any other plant. All these singularities contribute to one end. "As this plant blossoms late in the year, and, probably, would not have time to ripen its seeds before the access of winter which would destroy them, Providence has contrived its structure such, that this important office may be performed at a depth in the earth out of reach of the usual effects of frost."* That is to say, in the autumn nothing is done above ground but the business of impregnation; which is an affair between the antheræ and the stigmata. The maturation of the impregnated seed, which in other plants proceeds within a capsule, exposed together with the rest of the flower to the open air, is here carried on, and during the whole winter, within the heart, as we may say, of the earth, that is, "out of the reach of the usual effects of frosts." But then a new difficulty presents itself. Seeds, though perfected, are known not to vegetate at this depth in the earth. Our seeds therefore, tho' so safely lodged, would, after all, be lost to the purpose for which all seeds are intended. Lest this should be the case, "a second admirable provision is made to raise them above the surface when they are perfected, and to sow them at a proper distance:" viz. the germ grows up *in the spring*, upon a fruit-stalk, accompanied with leaves. The seeds now, in

* Ib. p. 360.

common with those of other plants, have the benefit of the summer, and are sown upon the surface. The order of vegetation externally is this. The plant produces its flowers in September; its leaves and fruits in the spring following.

V. I give the account of the dionæa muscipula, an extraordinary American plant, as some late authors have related it; but, whether we be yet enough acquainted with the plant to bring every part of this account to the test of repeated and familiar observation, I am unable to say. Its leaves are jointed, and furnished with two rows of strong prickles; their surfaces covered with a number of minute glands, which secrete a sweet liquor, that allures the approach of flies. When these parts are touched by the legs of flies, the two lobes of the leaf instantly spring up, the rows of prickles lock themselves fast together, and squeeze the unwary animal to death."* Here, under a new model, we recognize the ancient plan of nature; viz. the relation of parts and provisions to one another, to a common office, and to the utility of the organized body to which they belong. The attracting syrup, the rows of strong prickles, their position so as to interlock, the joints of the leaves; and, what is more than the rest, that singular irritability of their surfaces, by which they close at a touch; all bear a contributory part in producing an effect, connected either with the defence, or with the nutrition, of the plant.

CHAPTER XXI.

THE ELEMENTS.

WHEN we come to the elements, we take leave of our mechanics; because we come to those things,

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

of the organization of which, if they be organized, we are confeſſedly ignorant. This ignorance is implied by their name. To ſay the truth, our inveſtigations are ſtopped long before we arrive at this point. But then it is for our comfort to find, that a knowledge of the conſtitution of the elements is not neceſſary for us. For inſtance, as Addiſon has well obſerved, "we know *water* ſufficiently, when we know how to boil, how to freeze, how to evaporate, how to make it freſh, how to make it run or ſpout out, in what quantity and direction we pleaſe, without knowing what water is." The obſervation of this excellent writer has more propriety in it now, than it had at the time it was made: for the conſtitution, and the conſtituent parts of water, appear in ſome meaſure to have been lately diſcovered; yet it does not, I think, appear, that we can make any better or greater uſe of water ſince the diſcovery, than we did before it.

We can never think of the elements without reflecting upon the number of diſtinct uſes which are *conſolidated* in the ſame ſubſtance. The *air* ſupplies the lungs, ſupports fire, conveys ſound, reflects light, diffuſes ſmells, gives rain, wafts ſhips, bears up birds. [*Ex údatos ta panta;*] *water*, beſide maintaining its own inhabitants, is the univerſal nouriſher of plants, and through them of terreſtrial animals; is the baſis of their juices and fluids: dilutes their food, quenches their thirſt, floats their burthens. *Fire* warms, diſſolves, enlightens; is the great promoter of vegetation and life, if not neceſſary to the ſupport of both.

We might enlarge, to almoſt any length we pleaſed, upon each of theſe uſes; but it appears to me almoſt ſufficient to ſtate them. The few remarks, which I judge 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: (the moon has none:) 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 terrestrial surface. I think that every one of these uses will be understood upon the first mention of them, 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 as widely diffused, as are those of the air.

Another general quality of the atmosphere is, the power of evaporating fluids. The adjustment of this quality to our use is seen in its action upon the sea. In the sea, water and salt are mixed together most intimately; yet the atmosphere raises the water, and leaves the salt. Pure and fresh as drops of rain descend, they are collected from brine. If evaporation be solution, (which seems to be probable,) then the air dissolves the water, and not the salt. Upon whatever it be founded, the distinction is critical; so much so, that, when we attempt to imitate the process by art, we must regulate our distillation with great care and nicety, or, together with the water, we get the bitterness, or, at least, the distastefulness of the marine substance: and, after all, it is owing to this original elective power in the air, that we can effect the separation which we wish, by any art or means whatever.

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

By reſpiration, flame, putrefaction, air is rendered unfit for the ſupport of animal life. By the conſtant operation of theſe corrupting principles, the whole atmoſphere, if there were no reſtoring cauſes, would come at length to be deprived of its neceſſary degree of purity. Some of theſe cauſes ſeem to have been diſcovered, and their efficacy aſcertained by experiment. And ſo far as the diſcovery has proceeded, it opens to us a beautiful and a wonderful œconomy. *Vegetation* proves to be one of them. A ſprig of mint, corked up with a ſmall portion of foul air placed in the light, renders it again capable of ſupporting life or flame. Here therefore is a conſtant circulation of benefits maintained between the two great provinces of organized nature. The plant purifies what the animal had poiſoned: in return, the contaminated air is more than ordinarily nutritious to the plant. *Agitation with water* turns out to be another of theſe reſtoratives. The fouleſt air, ſhaken in a bottle with water for a ſufficient length of time, recovers a great degree of its purity. Here then again, allowing for the ſcale upon which nature works, we ſee the ſalutary effects of *ſtorms* and *tempeſts.*—The yeſty waves, which confound the heaven and the ſea, are doing the very thing which is done in the bottle. Nothing can be of greater importance to the living creation, than the ſalubrity of their atmoſphere. It ought to reconcile us therefore to theſe agitations of the elements, of which we ſometimes deplore the confequences, to know, that they tend powerfully to reftore to the air that purity, which fo many caufes are conftantly impairing.

II. In WATER, what ought not a little to be admired, are thofe negative qualities which conftitute its *purity*. Had it been vinous, or oleaginous, or acid; had the fea been filled, or the rivers flowed, with wine or milk; fifh, conftituted as they are, muft have died; plants, conftituted as they are, would have withered; the lives of animals, which feed upon plants, muft have perifhed. Its very *infipidity*, which is one of thofe negative qualities, renders it the beft of all menftrua. Having no tafte of its own, it becomes the fincere vehicle of every other. Had there been a tafte in water, be it what it might, it would have infected every thing we ate or drank, with an importunate repetition of the fame flavor.

Another thing in this element, not lefs to be admired, is the conftant *round* which it travels; and by which, without fuffering either adulteration or wafte, it is continually offering itfelf to the wants of the habitable globe. From the fea are exhaled thofe vapours which form the clouds. Thefe clouds defcend in fhowers, which, penetrating into the crevices of the hills, fupply fprings. Which fprings flow in little ftreams into the valleys; and, there uniting, become rivers. Which rivers, in return, feed the ocean. So there is an inceffant circulation of the fame fluid; and not one drop probably more or lefs now, than there was at the creation. A particle of water takes its departure from the furface of the fea, in order to fulfil certain important offices to the earth; and having executed the fervice which was affigned to it, returns to the bofom which it left.

Some have thought that we have too much water upon the globe; the fea occupying above three quarters of its whole furface. But the expanfe of ocean, immenſe as it is, may be no more than ſufficient to fertiliſe the earth. Or, independently of this reaſon, I know not why the ſea may not have as good a right to its place as the land. It may proportionably ſupport as many inhabitants; miniſter to as large an aggregate of enjoyment. The land only affords a habitable ſurface; the ſea is habitable to a great depth.

III. Of FIRE, we have ſaid that it *diſſolves*. The only idea probably which this term raiſed in the reader's mind was, that of fire melting metals, reſins, and ſome other ſubſtances, fluxing ores, running glaſs, and aſſiſting us in many of our operations, chymical or culinary. Now theſe are only uſes of an occaſional kind, and give us a very imperfect notion of what fire does for us. The grand importance of this diſſolving power, the great office indeed of fire in the œconomy of nature, is keeping things in a ſtate of ſolution, that is to ſay, in a ſtate of fluidity. Were it not for the preſence of heat, or of a certain degree of it, all fluids would be frozen. The ocean itſelf would be a quarry of ice: univerſal nature ſtiff and dead.

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

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

Light paſſes from the ſun to the earth in eleven minutes; a diſtance, which it would take a cannon ball twenty-five years, in going over. Nothing more need be ſaid to ſhew the velocity of light. Urged by ſuch a velocity, with what *force* muſt its particles drive againſt, I will not ſay the eye, the tendereſt of animal ſubſtances, but every ſubſtance, animate or inanimate, which ſtands in its way? It might ſeem to be a force ſufficient to ſhatter to atoms the hardeſt bodies.

How then is this effect, the conſequence of ſuch prodigious velocity, guarded againſt? By a proportionable *minuteneſs* of the particles of which light is compoſed. It is impoſſible for the human mind to imagine to itſelf any thing ſo ſmall as a particle of light. But this extreme exility, though difficult to conceive, it is eaſy to prove. A drop of tallow, expended in the wick of a farthing candle, ſhall ſhed forth rays ſufficient to fill a hemiſphere of a mile diameter; and to fill it ſo full of theſe rays, that an aperture not larger than the pupil of an eye, wherever it be placed within the hemiſphere, ſhall be ſure to receive ſome of them. What floods of light are continually poured from the ſun we cannot eſtimate; but the immenſity of the ſphere which is filled with its particles, even if it reached no further than the orbit of the earth, we can in ſome ſort compute: and we have reaſon to believe, that, throughout this whole region, the particles of light lie, in latitude at leaſt, near to one another. The ſpiſſitude of the ſun's rays at the earth is ſuch, that the number which falls upon a burning glaſs of an inch diameter, is ſufficient, when concentrated, to ſet wood on fire.

The tenuity and the velocity of particles of light, as aſcertained by ſeparate obſervations, may be ſaid to be proportioned to each other: both ſurpaſſing our utmoſt ſtretch of comprehenſion; but proportioned. And it is this proportion alone, which converts a tremendous element into a welcome viſitor.

It has been obſerved to me by a learned friend, as having often ſtruck his mind, that, if light had been made by a common artiſt, it would have been of one uniform *colour:* whereas, by its present composition, we have that variety of colours, which is of such infinite use to us for the distinguishing of objects; which adds so much to the beauty of the earth, and augments the stock of our innocent pleasures.

With which may be joined another reflection, viz. that, considering light as compounded of rays of seven different colours, (of which there can be no doubt, because it can be resolved into these rays by simply passing it through a prism,) the constituent parts must be well mixed and blended together, to produce a fluid, so clear and colourless, as a beam of light is, when received from the sun.

CHAPTER XXII.

ASTRONOMY.*

My opinion of Astronomy has always been, that it is *not* the best medium through which to prove the agency of an intelligent Creator; but that, this being proved, it shews, beyond all other sciences, the magnificence of his operations. The mind which is once convinced, it raises to sublimer views of the Deity, than any other subject offords; but is not so well adapted, as some other subjects are, to the purpose of argument. We are destitute of the means of examining the constitution of the heavenly bodies. The very simplicity of their appearance is against them. We see nothing, but bright points, luminous circles, or the phases of spheres reflecting the light which

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

falls upon them. Now we deduce design from relation, aptitude, and correspondence of *parts*. Some degree therefore of *complexity* is necessary to render a subject fit for this species of argument. But the heavenly bodies do not, except perhaps in the instance of Saturn's ring, present themselves to our observation as compounded of parts at all. This, which may be a perfection in them, is a disadvantage to us, as enquirers after their nature. They 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 sensible intermediate apparatus: whereby we are cut off from one principal ground of argumentation and analogy. We have nothing wherewith to compare them; no invention, no discovery, no operation or resource of art, which, in this respect, resembles them. Even those things which are made to imitate and represent them, such as orreries, planetaria, cœlestial globes, &c. bear no affinity to them, in the cause and principle by which their motions are actuated. I can assign for this difference a reason of utility, viz. a reason why, though the action of *terrestrial* bodies upon each other be, in almost all cases, through the intervention of solid or fluid substances, yet central attraction does not operate in this manner. It was necessary that the intervals between the planetary orbs should be devoid of any *inert* matter either fluid or solid, because such an intervening substance would, by its resistance, destroy those very motions, which attraction is employed to preserve. This may be a final cause of the difference; but still the difference destroys the analogy.

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

After all, the real ſubject of admiration is, that we underſtand ſo much of aſtronomy as we do. That an animal confined to the ſurface of one of the planets; bearing a leſs proportion to it, than the ſmalleſt microſcopic inſect does to the plant it lives upon; that this little, buſy, inquiſitive creature, by the uſe of ſenſes which were given to it for its domeſtic neceſſities, and by means of the aſſiſtance of thoſe ſenſes which it has had the art to procure, ſhould have been enabled to obſerve the whole ſyſtem of worlds to which its own belongs; the changes of place of the immenſe globes which compoſe it; and with ſuch accuracy, as to mark out, beforehand, the ſituation in the heavens in which they will be found at any future point of time; and that theſe bodies, after ſailing through regions of void and trackleſs ſpace, ſhould arrive at the place where they were expected, not within a minute, but within a few ſeconds of a minute, of the time prefixed and predicted: all this is wonderful, whether we refer our admiration to the conſtancy of the heavenly motions themſelves, or to the perſpicacity and preciſion with which they have been noticed by mankind. Nor is this the whole, nor indeed the chief part, of what aſtronomy teaches. By bringing reaſon to bear upon obſervation, (the acuteſt reaſoning upon the exacteſt obſervation,) the aſtronomer has been able, out of the confuſion (for ſuch it is) under which the motions of the heavenly bodies preſent themſelves to the eye of a mere gazer upon the ſkies, to elicit their order and their real paths.

Our knowledge therefore of aſtronomy is admirable, though imperfect; and, amidſt the confeſſed deſiderata and deſideranda, which impede our inveſtigation of the wiſdom of the Deity, in theſe the grandeſt of his works, there are to be found, in the phænomena, aſcertained circumſtances and laws, ſufficient to indicate an intellectual agency in three of its principal operations, viz. in choosing, in determining, in regulating; in *choosing*, out of a boundless variety of suppositions which were equally possible, that which is beneficial; in *determining*, what, left to itself, had a thousand chances against conveniency, for one in its favor; in *regulating* subjects, as to quantity and degree, which, by their nature, were unlimited with respect to either. It will be our business to offer, under each of these heads, a few instances, such as best admit of a popular explication.

I. Amongst proofs of choice, one is, fixing the source of light and heat in the *centre* of the system. The sun is ignited and luminous; the planets, which move round him, cold and dark. There seems to be no antecedent necessity for this order. The sun might have been an opaque mass: some one, or two, or more, or any, or all, of the planets, globes of fire. There is nothing in the nature of the heavenly bodies, which requires that those which are stationary should be on fire, that those which move should be cold: for, in fact, comets are bodies on fire, yet revolve round a centre: nor does this order obtain between the primary planets and their secondaries, which are all opaque. When we consider, therefore, that the sun is one; that the planets going round it are, at least, seven; that it is indifferent to their nature which are luminous and which are opaque; and also, in what order with respect to each other, these two kinds of bodies are disposed; we may judge of the improbability of the present arrangement taking place by chance.

If, by way of accounting for the state in which we find the solar system, it be alledged (and this is one amongst the guesses of those who reject an intelligent Creator) that the planets themselves are only cooled or cooling masses, and were once, like the sun, many thousand times hotter than red hot iron; then it follows, that the sun also himself must be in his progress towards growing cold; which puts an end to the possibility of his having existed, as he is, from eternity. This consequence arises out of the hypothesis with still more certainty, if we make a part of it, what the philosophers who maintain it, have usually taught, that the planets were originally masses of matter struck off, in a state of fusion, from the body of the sun, by the percussion of a comet, or by a shock from some other cause with which we are not acquainted: for, if these masses, partaking of the nature and substance of the sun's body, have in process of time lost their heat, that body itself, in time likewise, no matter in how much longer time, must lose its heat also; and therefore be incapable of an eternal duration in the state in which we see it, either for the time to come, or the time past.

The preference of the present to any other mode of distributing luminous and opaque bodies, I take to be evident. It requires more astronomy than I am able to lay before the reader, to shew, in its particulars, what would be the effect to the system, of a dark body at the centre, and of one of the planets being luminous: but I think it manifest, without either plates or calculation, first, that, supposing the necessary proportion of magnitude between the central and the revolving bodies to be preserved, the ignited planet would not be sufficient to illuminate and warm the rest of the system; secondly, that its light and heat would be imparted to the other planets, much more irregularly than light and heat are now received from the sun.

(*) II. Another thing, in which a choice appears to be exercised; and in which, amongst the possibilities out of which the choice was to be made, the number of those which were wrong, bore an infinite proportion to the number of those which were right, is in what geometricians call the *axis of rotation.* This matter I will endeavor to explain. The earth, it is well known, is not an exact globe, but an oblate spheroid, something like an orange. Now the axis of rotation, or the diameters upon which such a body may be made to turn round, are as many as can be drawn through its centre to opposite points upon its whole surface: but of these axis none are *permanent*, except either its shortest diameter, i. e. that which passes through the heart of the orange from the place where the stalk is inserted into it, and which is but one; or its longest diameters, at right angles with the former, which must all terminate in the single circumference which goes round the thickest part of the orange. This shortest diameter is that upon which in fact the earth turns; and it is, as the reader sees, what it ought to be, a permanent axis: whereas, had blind chance, had a casual impulse, had a stroke or push at random, set the earth a-spinning, the odds were infinite, but that they had sent it round upon a wrong axis. And what would have been the consequence? The difference between a permanent axis and another axis is this. When a spheroid in a state of rotatory motion gets upon a permanent axis, it keeps there; it remains steady and faithful to its position; its poles preserve their direction with respect to the plane and to the centre of its orbit: but, whilst it turns upon an axis which is *not* permanent, (and the number of those, we have seen, infinitely exceeds the number of the other,) it is always liable to shift and vacillate from one axis to another, with a corresponding change in the inclination of its poles. Therefore, if a planet once set off revolving upon any other than its shortest, or one of its longest axis, the poles on its surface would keep perpetually changing, and it never would attain a permanent axis of rotation. The effect of this unfixedness and instability would be, that the equatorial parts of the earth might become the polar, or the polar the equatorial; to the utter destruction of plants and animals, which are not capable of interchanging their ſituations, but are reſpectively adapted to their own. As to ourſelves, inſtead of rejoicing in our temperate zone, and annually preparing for the moderate viciſſitude, or rather the agreeable ſucceſſion of ſeaſons, which we experience and expect, we might come to be locked up in the ice and darkneſs of the arctic circle, with bodies neither inured to its rigors, nor provided with ſhelter or defence againſt them. Nor would it be much better, if the trepidation of our pole, taking an oppoſite courſe, ſhould place us under the heats of a vertical ſun. But, if it would fare ſo ill with the human inhabitant, who can live under greater varieties of latitude than any other animal, ſtill more noxious would this tranſlation of climate have proved to life in the reſt of the creation; and, moſt perhaps of all, in plants. The habitable earth, and its beautiful variety, might have been deſtroyed, by a ſimple miſchance in the axis of rotation.

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

Calculations were made a few years ago of the mean denſity of the earth, by comparing the force of its attraction with the force of attraction of a rock of granite, the bulk of which could be aſcertained: and the upſhot of the calculation was, that the earth upon an average, through its whole ſphere, has twice the denſity of granite, or about five times that of water. Therefore it cannot be a hollow ſhell, as ſome have formerly ſuppoſed: nor can its internal parts be occupied by central fire, or by water. The ſolid parts muſt greatly exceed the fluid parts: and the probability is, that it is a ſolid maſs throughout, compoſed of ſubſtances, more ponderous the deeper we go. Nevertheleſs, we may conceive the preſent face of the earth to have originated from the revolution of a ſphere, covered with a ſurface of a compound mixture; the fluid and ſolid parts ſeparating, as the ſurface became quieſcent. Here then comes in the *moderating* hand of the Creator. If the water had exceeded its preſent proportion, even but by a trifling quantity compared with the whole globe, all the land would have been covered: had there been much leſs than there is, there would not have been enough to fertilize the continent. Had the exſiccation been progreſſive, ſuch as we may ſuppoſe to have been produced by an evaporating heat, how came it to ſtop at the point at which we ſee it? Why did it not ſtop ſooner; why at all? The mandate of the Deity will account for this: nothing elſe will.

IV. OF CENTRIPETAL FORCES. By virtue of the ſimpleſt law that can be imagined, viz. that a body *continues* in the ſtate in which it is, whether of motion or reſt; and, if in motion, goes on in the line in which it was proceeding, and with the ſame velocity, *unleſs* there be ſome cauſe for change: by virtue, I ſay, of this law, it comes to paſs (what may appear to be a ſtrange conſequence) that caſes ariſe, in which attraction, inceſſantly drawing a body towards a centre, never brings, nor ever will bring, the body to that centre, but keep it in eternal circulation round it. If it were poſſible to fire off a cannon ball with a velocity of five miles in a ſecond, and the reſiſtance of the air could be taken away, the cannon ball would for ever wheel round the earth, inſtead of falling down upon it. This is the principle which ſuſtains the heavenly motions. The Deity having appointed this law to matter, than which, as we have ſaid before, no law could be more ſimple, has turned it to a wonderful account in conſtructing planetary ſyſtems.

The actuating cauſe in theſe ſyſtems, is an attraction which varies reciprocally as the ſquare of the diſtance: that is, at double the diſtance, has a quarter of the force; at half the diſtance, four times the ſtrength; and ſo on. Now, concerning this law of variation, we have three things to obſerve; firſt, that attraction, for any thing we know about it, was juſt as capable of one law of variation as of another: ſecondly; that, out of an infinite number of poſſible laws, thoſe which were admiſſible for the purpoſe of ſupporting the heavenly motions, lay within certain narrow limits: thirdly; that of the admiſſible laws, or thoſe which come within the limits preſcribed, the law that actually prevails is the moſt beneficial. So far as theſe propoſitions can be made out, we may be ſaid, I think, to prove choice and *regulation;* choice, out of boundleſs variety; and regulation, of that which, by its own nature, was, in reſpect of the property regulated, indifferent and indefinite.

I. Firſt then, attraction, for any thing we know about it, was originally indifferent to all laws of variation depending upon change of diſtance, i. e. juſt as ſuſceptible of one law as of another. It might have been the ſame at all diſtances. It might have increaſed as the diſtance increaſed. Or it might have diminished with the increase of the distance, yet in ten thousand different proportions from the present. It might have followed no stated law at all. If attraction be, what Cotes with many other Newtonians have thought it, a primordial property of matter, not dependent upon, or traceable to, any other material cause, then, by the very nature and definition of a primordial property, it stood indifferent to all laws. If it be the agency of something immaterial, then also, for any thing we know of it, it was indifferent to all laws. If the revolution of bodies round a centre depend upon vortices, neither are these limited to one law more than another.

There is, I know, an account given of attraction, which should seem, in its very cause, to assign to it the law, which we find it to observe, and which, therefore, makes that law, a law, not of choice, but of necessity: and it is the account, which ascribes attraction to an *emanation* from the attracting body. It is probable, that the influence of such an emanation will be proportioned to the spissitude of the rays, of which it is composed: which spissitude, supposing the rays to issue in right lines on all sides from a point, will be reciprocally as the square of the distance.—The mathematics of this solution we do not call in question: the question with us is, whether there be any sufficient reason to believe, that attraction is produced by an emanation. For my part, I am totally at a loss to comprehend, how particles streaming *from* a centre, should draw a body *towards* it. The impulse, if impulse it be, is all the other way. Nor shall we find less difficulty in conceiving a conflux of particles, incessantly flowing to a centre, and carrying down all bodies along with it, that centre also itself being in a state of rapid motion through absolute space; for, by what source is the stream fed, or what becomes of the accumulation? Add to which, that it feems to imply a contrariety of properties, to fuppofe an æthereal fluid to *act* but not to *refift*; powerful enough to carry down bodies with great force towards a centre, yet, inconfiftently with the nature of inert matter, powerlefs and perfectly yielding with refpect to the motions which refult from the projectile impulfe. By calculations drawn from ancient notices of eclipfes of the moon, we can prove, that, if fuch a fluid exift at all, its refiftance has had no fenfible effect upon the moon's motion for two thoufand five hundred years. The truth is, except this one circumftance of the variation of the attracting force at different diftances agreeing with the variation of the fpiffitude, there is no reafon whatever to fupport the hypothefis of an emanation; and, as it feems to me, almoft infuperable reafons againft it.

II. (*) Our fecond propofition is, that, whilft the poffible laws of variation were infinite, the *admiffible* laws, or the laws compatible with the prefervation of the fyftem, lay within narrow limits. If the attracting force had varied according to any *direct* law of the diftance, let it have been what it would, great deftruction and confufion would have taken place.—The direct fimple proportion of the diftance would, it is true, have produced an ellipfe; but the perturbing forces would have acted with fo much advantage, as to be continually changing the dimenfions of the ellipfe, in a manner inconfiftent with our terreftrial creation. For inftance; if the planet Saturn, fo large and fo remote, had attracted the earth, both in proportion to the quantity of matter contained in it, which it does; and alfo in any proportion to its diftance, i. e. if it had pulled the harder for being the further off, (inftead of the reverfe of it,) it would have dragged the globe which we inhabit out of its courfe, and have perplexed its motions, to a degree incompatible with our fecurity, our enjoyments, and probably our exiftence. Of the *inverse* laws, if the centripetal force had changed as the cube of the distance, or in any higher proportion, that is, (for I speak to the unlearned,) if, at double the distance, the attractive force had been diminished to an eighth part, or to less than that, the consequence would have been, that the planets, if they once began to approach, the sun would have fallen into his body; if they once, though by ever so little, increased their distance from the centre, would for ever have receded from it. The laws therefore of attraction, by which a system of revolving bodies could be upheld in their motions, lie within narrow limits, compared with the possible laws. I much underrate the restriction, when I say, that in a scale of a mile they are confined to an inch. All direct ratios of the distance are excluded, on account of danger from perturbing forces: all reciprocal ratios, except what lie beneath the cube of the distance, by the demonstrable consequence, that every the least change of distance, would, under the operation of such laws, have been fatal to the repose and order of the system. We do not know, that is, we seldom reflect, how interested we are in this matter. Small irregularities may be endured; but, changes within these limits being allowed for, the permanency of our ellipse is a question of life and death to our whole sensitive world.

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

(*) 1. Whilſt this law prevails between each particle of matter, the *united* attraction of a ſphere, compoſed of that matter, obſerves the ſame law. This property of the law is neceſſary, to render it applicable to a ſyſtem compoſed of ſpheres, but it is a property which belongs to no other law of attraction that is admiſſible. The law of variation of the united attraction is in no other caſe the ſame as the law of attraction of each particle, one caſe excepted, and that is of the attraction varying directly as the diſtance; the inconveniency of which law in other reſpects we have already noticed.

(*) 2. Under the ſubſiſting law, the *apſides*, the returning points, or points of greateſt and leaſt diſtance from the centre, are *quieſcent*, and, therefore, the body moves every revolution in exactly the ſame path relative to the attracting centre: which it would not do under any other law whatever, except that of the direct ratio of the diſtance, which we have ſeen to be objectionable. The planetary ſyſtem required that the law of attraction ſhould be a law which gave an orbit returning into itſelf. Now, out of an infinite number of laws, admiſſible and inadmiſſible, out of a vaſt variety even of admiſſible laws, there are few, except the actual law, which would do this. Here then is choice.

(*) 3. All ſyſtems muſt be liable to *perturbations*. And therefore to guard againſt theſe perturbations, or rather to guard againſt their running to deſtructive lengths, is perhaps the ſtrongeſt evidence of care and foreſight 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, that the action of the parts of our syſtem upon one another will not cauſe permanently increaſing irregularities, but merely periodical ones: that is, they will come to a limit, and then go back again. This we can demonſtrate only of a ſyſtem, in which the following properties concur, viz. that the force ſhall be inverſely as the ſquare of the diſtance; the maſſes of the revolving bodies ſmall, compared with that of the body at the centre; the orbits not much inclined to one another; and their eccentricity little. In ſuch a ſyſtem the grand points are ſecure. The mean diſtances and periodic times, upon which depend our temperature, and the regularity of our year, are conſtant. The eccentricities, it is true, will ſtill vary, but ſo ſlowly, and to ſo ſmall an extent, as to produce no inconveniency from fluctuation of temperature and ſeaſon. The ſame as to the obliquity of the planes of the orbits. For inſtance, the inclination of the ecliptic to the equator will never change above two degrees, (out of ninety,) and that will require many thouſand years in performing.

It has been rightly alſo remarked, that, if the great planets Jupiter and Saturn had moved in lower ſpheres, their influences would have had much more effect as to diſturbing the planetary motions than they now have. While they revolve at ſo great diſtances from the reſt, they act almoſt equally on the Sun and on the inferior planets, which has nearly the ſame conſequence as not acting at all upon either.

If it be ſaid that the planets might have been ſent round the Sun in exact circles, in which caſe, no change of diſtance from the centre taking place, the law of variation of the attracting power would have never come in queſtion; one law would have ſerved as well as another; an anſwer to the ſcheme may be drawn from the conſideration of theſe ſame perturbing forces. The ſyſtem retaining in other reſpects its present constitution, though the planets had been at first sent round in exact circular orbits, they could not have kept them: and if the law of attraction had not been what it is, (or, at least, if the prevailing law had transgressed the limits above assigned,) every evagation would have been fatal: the planet once drawn, as drawn it necessarily must have been, out of its course, would have wandered in endless error.

(*) V. What we have seen in the law of the centripetal force, viz. a choice guided by views of utility, and a choice of one law out of thousands which might equally have taken place, we see no less in the *figures* of the planetary orbits. It was not enough to fix the law of the centripetal force, though by the wisest choice, for, even under that law, it was still competent to the planets to have moved in paths possessing so great a degree of eccentricity, as, in the course of every revolution, to be brought very near to the sun, and carried away to immense distances from him.—The comets actually move in orbits of this sort: and, had the planets done so, instead of going round in orbits nearly circular, the change from one extremity of temperature to another must, in ours at least, have destroyed every animal and plant upon its surface.—Now, the distance from the centre at which a planet sets off, and the absolute force of attraction at that distance, being fixed, the figure of his orbit, its being a circle, or nearer to, or further off from, a circle, viz. a rounder or a longer oval, depends upon two things, the velocity with which, and the direction in which, the planet is projected. And these, in order to produce a right result, must be both brought within certain narrow limits. One, and only one, velocity, united with one, and only one, direction, will produce a perfect circle. And the velocity must be near to this velocity, and the direction also near to this direction, to produce orbits, such as the planetary orbits are, nearly circular; that is, ellipses with small eccentricities. The velocity and the direction must *both* be right. If the velocity be wrong, no direction will cure the error; if the direction be in any considerable degree oblique, no velocity will produce the orbit required. Take for example the attraction of gravity at the surface of the earth. The force of that attraction being what it is, out of all the degrees of velocity, swift and slow, with which a ball might be shot off, none would answer the purpose of which we are speaking but what was nearly that of five miles in a second. If it were less than that, the body would not get round at all, but would come to the ground: if it were in any considerable degree more than that, the body would take one of those eccentric courses, those long ellipses, of which we have noticed the inconveniency. If the velocity reached the rate of seven miles in a second, or went beyond that, the ball would fly off from the earth, and never be heard of more.—In like manner with respect to the *direction*; out of the innumerable angles in which the ball might be sent off, I mean angles formed with a line drawn to the centre, none would serve but what was nearly a right one; out of the various directions in which the cannon might be pointed, upwards and downwards, every one would fail, but what was exactly or nearly horizontal. The same thing holds true of the planets; of our own amongst the rest. We are entitled therefore to ask, and to urge the question, Why did the projectile velocity, and projectile direction of the earth happen to be nearly those which would retain it in a *circular* form? Why not one of the infinite number of velocities, one of the infinite number of directions, which would have made it approach much nearer to, or recede much further from, the sun?

The planets going round, all in the same direction, and all nearly in the same plane, afforded to Buffon a ground for asserting, that they had all been shivered from the sun by the same stroke of a comet, and by that stroke projected into their present orbits. Now, beside that this is to attribute to chance the fortunate concurrence of velocity and direction which we have been here noticing, the hypothesis, as I apprehend, is inconsistent with the physical laws by which the heavenly motions are governed. If the planets were struck off from the surface of the sun, they would return to the surface of the sun again. Or, if, to get rid of this difficulty, we suppose, that the same violent blow, which shattered the sun's surface, and separated large fragments from it, pushed also the sun himself out of his place; a question of no less difficulty presents itself, namely, when once put into motion, what should *stop* him. The hypothesis is also contradicted by the vast difference which subsists between the *diameters* of the planetary orbits. The distance of Saturn from the sun (to say nothing of the Georgium sidus) is nearly 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, with whatever difference of direction or velocity they set off, could not have been found at these different distances from the centre, still retaining their nearly circular orbits. They must have been carried to their proper distances, before they were projected.*

* "If we suppose the matter of the system to be accumulated in the centre by its gravity, *no* mechanical principles, with the assistance of this power of gravity, could separate the vast mass into such parts as the sun and planets; and, after carrying them to their different distances, project them in their several directions, preserving still the equality of action and reaction, or the state of the centre of gravity of the system. Such an exquisite structure of things could only arise from the contrivance and powerful influences of an intelligent, free, and most potent agent. The same powers, therefore, which, at present, govern the material universe, and conduct its various motions, are *very different* from those, which were necessary, to have produced it from nothing, or to have disposed it in the admirable form in which it now proceeds."—*Maclaurin's Account of Newton's Phil.* p. 407. ed. 3.

To conclude: In aſtronomy, the great thing is to raiſe the imagination to the ſubject, and that oftentimes in oppoſition to the impreſſion made upon the ſenſes. An alluſion, for example, muſt be got over, ariſing from the diſtance at which we view the heavenly bodies, viz. the apparent *ſlowneſs* of their motions. The moon ſhall take ſome hours in getting half a yard from a ſtar which it touched. A motion ſo deliberate, we may think eaſily guided. But what is the fact? The moon, in fact, is, all this while, driving through the heavens, at the rate of conſiderably more than two thouſand miles in an hour; which is more than double of that, with which a ball is ſhot off from the mouth of a cannon. Yet is this prodigious rapidity as much under government, as if the planet proceeded ever ſo ſlowly, or were conducted in its courſe inch by inch. It is alſo difficult to bring the imagination to conceive (what yet, to judge tolerably of the matter, it is neceſſary to conceive) how *looſe*, if we may ſo expreſs it, the heavenly bodies are. Enormous globes, held by nothing, confined by nothing, are turned into free and boundleſs ſpace, each to ſeek its courſe by the virtue of an inviſible principle; but a principle, one, common, and the ſame, in all; and aſcertainable. To preſerve ſuch bodies from being loſt, from running together in heaps, from hindering and diſtracting one another's motions, in a degree inconſiſtent with any continuing order; h. e. to cauſe them to form planetary ſyſtems, ſyſtems that, when formed, can be upheld, and, moſt eſpecially, ſyſtems accommodated to the organized and ſenſitive natures which the planets ſuſtain, as we know to be the caſe, where alone we can know what the caſe is, upon our earth: all this requires an intelligent interpoſition, becauſe it can be demonſtrated concerning it, that it requires an adjuſtment of force, diſtance, direction, and velocity, out of the reach of chance to have produced; an adjuſtment, in its view to utility ſimilar to that which we ſee in ten thouſand ſubjects of nature which are nearer to us, but in power, and in the extent of ſpace through which that power is exerted, ſtupendous.

But many of the heavenly bodies, as the ſun and fixed ſtars, are *ſtationary*. Their reſt muſt be the effect of an abſence or of an equilibrium of attractions. It proves alſo that a projectile impulſe was originally given to ſome of the heavenly bodies, and not to others. But further; if attraction act at all diſtances, there can be only one quieſcent centre of gravity in the univerſe: and all bodies whatever muſt be approaching this centre, or revolving round it. According to the firſt of theſe ſuppoſitions, if the duration of the world had been long enough to allow of it, all its parts, all the great bodies of which it is compoſed, muſt have been gathered together in a heap round this point. No changes however which have been obſerved, afford us the ſmalleſt reaſon for believing that either the one ſuppoſition or the other is true: and then it will follow, that attraction itſelf is controled or ſuſpended by a ſuperior agent; that there is a power above the higheſt of the powers of material nature; a will which reſtrains and circumſcribes the operations of the moſt extenſive.

CHAPTER XXIII.

OF THE PERSONALITY OF THE DEITY.

CONTRIVANCE, if eſtabliſhed, appears to me to prove every thing which we wiſh to prove. Amongſt other things it proves the *perſonality* of the Deity, as diſtinguiſhed from what is ſometimes called nature, ſometimes called a principle: which terms, in the mouths of those who use them philosophically, seem to be intended, to admit and to express an efficacy, but to exclude and to deny a personal agent. Now that which can contrive, which can design, must be a person. These capacities constitute personality, for they imply consciousness, and thought. They require that which can perceive an end or purpose; as well as the power of providing means, and of directing them to their end.* They require a centre in which perceptions unite, and from which volitions flow; which is mind. The acts of a mind prove the existence of a mind: and in whatever a mind resides is a person. The seat of intellect is a person. We have no authority to limit the properties of mind to any particular corporal form, or to any particular circumscription of space. These properties subsist, in created nature, under a great variety of sensible forms. Also every animated being has its *sensorium*, that is, a certain portion of space, within which perception and volition are exerted. This sphere may be enlarged to an indefinite extent; may comprehend the universe: and, being so imagined, may serve to furnish us with as good a notion, as we are capable of forming, of the *immensity* of the divine nature, i. e. of a Being, infinite, as well in essence, as in power; yet nevertheless a person.

"No man hath seen God at any time." And this, I believe, makes the great difficulty. Now it is a difficulty which chiefly arises from our not duly estimating the state of our faculties. The Deity, it is true, is the object of none of our senses: but reflect what limited capacities animal senses are. Many animals seem to have but one sense, or perhaps two at the most, touch and taste. Ought such an animal to conclude against the existence of smells, sounds, and colours? To another species is given the sense of

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

ſmelling. This is an advance in the knowledge of the powers and properties of nature: but, if this favored animal ſhould infer from its ſuperiority over the claſs laſt deſcribed, that it perceived every thing which was perceptible in nature, it is known to us, though perhaps not ſuſpected by the animal itſelf, that it proceeded upon a falſe and preſumtuous eſtimate of its faculties. To another is added the ſenſe of hearing; which lets in a claſs of ſenſations entirely unconceived by the animal before ſpoken of; not only diſtinct, but remote from any which *it* had ever experienced, and greatly ſuperior to them. Yet this laſt animal has no more ground for believing, that its ſenſes comprehend all things, and all properties of things, which exiſt, than might have 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* receive no diſtinguiſhable impreſſions. Is it then to be wondered at, that it ſhould, in ſome meaſure, be the ſame with the divine nature?

Of this however we are certain, that, whatever the Deity be, neither the *univerſe*, nor any part of it which we ſee, can be he. The univerſe itſelf is merely a collective name: its parts are all which are real; or which are *things*. Now inert matter is out of the queſtion; and organized ſubſtances include marks of contrivance. But whatever includes marks of contrivance, whatever, in its conſtitution, teſtifies deſign, neceſſarily carries us to ſomething beyond itſelf, to ſome other being, to a deſigner prior to, and out of, itſelf. No animal, for inſtance, can have contrived its own limbs and ſenſes; can have been the author to itſelf of the deſign with which they were conſtructed. That ſuppoſition involves all the abſurdity of ſelf-creation, i. e. of acting without exiſting. Nothing can be God, which is ordered by a wiſdom and a will, which itſelf is void of: which is indebted for any of its properties to contrivance *ab extra*. The *not* having that in his nature which requires the exertion of another prior being, (which property is ſometimes called ſelf-ſufficiency, and ſometimes ſelf-comprehenſion,) appertains to the Diety, as his eſſential diſtinction, and removes his nature from that of all things which we ſee. Which conſideration contains the anſwer to a queſtion that has ſometimes been aſked, namely, Why, ſince ſomething or other muſt have exiſted from eternity, may not the preſent univerſe be that ſomething? The contrivance, perceived in it, proves that to be impoſſible. Nothing contrived, can, in a ſtrict and proper ſenſe, be eternal, foraſmuch as the contriver muſt have exiſted before the contrivance.

Wherever we ſee marks of contrivance, we are led for its cauſe to an *intelligent* author. And this tranſition of the underſtanding is founded upon uniform experience. We ſee intelligence conſtantly contriving, that is, we ſee intelligence conſtantly producing effects, marked and diſtinguiſhed by certain properties; not certain particular properties, but by a kind and claſs of properties, ſuch as relation to an end, relation of parts to one another, and to a common purpoſe. We ſee, wherever we are witneſſes to the actual formation of things, nothing except intelligence producing effects ſo marked and diſtinguiſhed. Furniſhed with this experience, we view the productions of nature. We obſerve *them* alſo marked and diſtinguiſhed in the ſame manner. We wiſh to account for their origin. Our experience ſuggeſts a cauſe perfectly adequate to this account. No experience, no ſingle inſtance or example, can be offered in favor of any other. In this cauſe therefore we ought to reſt: in this cauſe the common ſenſe of mankind has in fact reſted, becauſe it agrees with that, which, in all caſes, is the foundation of knowledge, the undeviating courſe of their experience. The reaſoning is the ſame, as that, by which we conclude any ancient appearances to have been the effects of volcanos or inundations, namely, becauſe they reſemble the effects which fire and water produce before our eyes; and becauſe we have never known theſe effects to reſult from any other operation. And this reſemblance may ſubſiſt in ſo many circumſtances, as not to leave us under the ſmalleſt doubt in forming our opinion.

Men are not deceived by this reaſoning; for whenever it happens, as it ſometimes does happen, that the truth comes to be known by direct information, it turns out to be what was expected. In like manner, and upon the ſame foundation, (which in truth is that of experience,) we conclude that the works of nature proceed from intelligence and deſign, becauſe, in the properties of relation to a purpoſe, ſubſerviency to an uſe, they reſemble what intelligence and deſign are conſtantly producing, and what nothing except intelligence and deſign ever produced at all. Of every argument, which would raiſe a queſtion as the ſafety of this reaſoning, it may be obſerved, that, if ſuch argument be liſtened to, it leads to the inference, not only that the preſent order of nature is inſufficient to prove the exiſtence of an intelligent Creator, but that no imaginable order would be ſufficient to prove it; that *no* contrivance, were it ever ſo mechanical, ever ſo preciſe, ever ſo clear, ever ſo perfectly like thoſe which we ourſelves employ, would ſupport this concluſion. A doctrine, to which, I conceive, no ſound mind can aſſent.

The force however of the reaſoning is ſometimes ſunk by our taking up with mere names. We have already noticed,* and we muſt here notice again, the miſapplication of the term "law," and the miſtake 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 of 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 an-

* Ch. I. ſ. vii.

ſwer 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 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.

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 hundred different, and all uſeful movements, if a hundred different and well-deviſed ſets of wheels be placed between it and the final effect, e. g. may point out the hour of the day, the day of the month, the age of the moon, the poſition of the planets, the cycle of the years, and many other ſerviceable notices; and theſe movements may fulfil their purpoſes with more or leſs perfection, according as the mechaniſm is better or worſe contrived, or better or worſe executed, or in a better or worſe ſtate of repair: *but, in all caſes, it is neceſſary that the ſpring act at the centre.* The courſe of our reaſoning upon ſuch a ſubject would be this. By inſpecting the watch, even when ſtanding ſtill, we get a proof of contrivance, and of a contriving mind, having been employed about it. In the form and obvious relation of its parts we ſee enough to convince us of this. If we pull the works in pieces, for the purpoſe of a cloſer examination, we are ſtill more fully convinced. But, when we ſee the watch *going*, we ſee proof of another point, viz. that there is a power ſomewhere and ſomehow or other, applied to it; a power in action; that there is more in the ſubject than the mere wheels of the machine; that there is a ſecret ſpring or a gravitating plummet; in a word, that there is force and energy, as well as mechaniſm.

So then, the watch in motion eſtabliſhes to the obſerver two concluſions: one; that thought, contrivance, and deſign, have been employed in the forming, proportioning, and arranging of its parts; and that, whoever or wherever he be, or were, ſuch a contriver there is, or was: the other; that force or power, diſtinct from mechaniſm, is, at this preſent time acting upon it. If I ſaw a hand-mill even at reſt, I ſhould ſee contrivance; but, if I ſaw it grinding, I ſhould be aſſured that a hand was at the windlaſs, though in another room. It is the ſame in nature. In the works of nature we trace mechaniſm; and this alone proves contrivance: but living, active, moving, productive nature, proves alſo the exertion of a power at the centre; for, wherever the power reſides, may be denominated the centre.

The intervention and diſpoſition of what are called "*ſecond cauſes*" fall under the ſame obſervation. This diſpoſition is or is not mechaniſm, according as we can or cannot trace it by our ſenſes, and means of examination. That is all the difference there is; and it is a difference which reſpects our faculties, not the things themſelves. Now where the order of ſecond cauſes is mechanical, what is here ſaid of mechaniſm ſtrictly applies to it. But it would be always mechaniſm (natural chymiſtry, for inſtance, would be mechanifm) if our fenfes were acute enough to defcry it. Neither mechanifm, therefore, in the works of nature, nor the intervention of what are called fecond caufes, (for I think that they are the fame thing,) excufe the neceffity of an agent diftinct from both.

If, in tracing thefe caufes, it be faid, that we find certain general properties of matter, which have nothing in them that befpeaks intelligence, I anfwer, that, ftill, the *managing* of thefe properties, the pointing and directing them to the ufes which we fee made of them, demands intelligence in the higheft degree. For example, fuppofe animal fecretions to be elective attractions, and that fuch and fuch attractions univerfally belong to fuch and fuch fubftances; in all which there is no intellect concerned; ftill the choice and collocation of thefe fubftances, the fixing upon right fubftances and difpofing them in right places, muft be an act of intelligence. What mifchief would follow, were there a fingle tranfpofition of the fecretery organs; a fingle miftake in arranging the glands which compofe them?

There may be many fecond caufes, and many courfes of fecond caufes, one behind another, between what we obferve of nature, and the Deity; but there muft be intelligence fomewhere; there muft be more in nature than what we fee; and, amongft the things unfeen, there muft be an intelligent, defigning, author. The philofopher beholds with aftonifhment the production of things around him. Unconfcious particles of matter take their ftations, and feverally range themfelves in an order, fo as to become collectively plants or animals, i. e. organized bodies, with parts bearing ftrict and evident relation to one another, and to the utility of the whole: and it fhould feem that thefe particles could not move in any other way than as they do, for they teftify not the fmalleft fign of choice, or liberty, or discretion. There may be plastic natures, particular intelligent beings, guiding these motions in each case: or they may be the result of trains of mechanical dispositions, fixed beforehand by an intelligent appointment, and kept in action by a power at the centre. 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, is sometimes nothing more than in the *name;* which name, 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 principle, (if such he choose to call it,) what this mode of production 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 callicoes, the patterns of diapers and damasks, to these as principles, pretend to dispense with intention, thought, and contrivance, on the part of the artist; or to dispense, indeed, with the necessity of any artist at all, either in the manufactory of the article, or in the fabrication of the machinery by which the manufactory was carried on.

And, after all, how, or in what sense, is it true, that animals produce their *like*? A butterfly, with a proboscis instead of a mouth, with four wings and six legs, produces a hairy caterpillar, with jaws and teeth, and fourteen feet. A frog produces a tadpole. A black beetle, with gauze wings and a crusty covering, produces a white, smooth, soft worm: an ephemeron fly, a cod-bait maggot. These, by a progress through different stages of life, and action, and enjoyment, (and, in each state, provided with implements and organs appropriated to the temporary nature which they bear,) arrive at last at the form and fashion of the parent animal. But all this is process, not principle; and proves, moreover, that the property of animated bodies of producing their like, belongs to them, not as a primordial property, not by any blind necessity in the nature of things, but as the effect of œconomy, wisdom, and design; because the property itself, assumes diversities, and submits to deviations, dictated by intelligible utilities, and serving distinct purposes of animal happiness.

The opinion, which would consider "generation" as a *principle* in nature; and which would assign this principle as the cause, or endeavor to satisfy our minds with such a cause, of the existence of organized bodies, is confuted, in my judgment, not only by every mark of contrivance discoverable in those bodies, for which it gives us no contriver, offers no account whatever; but also by the further consideration, that things generated possess a clear relation to things *not* generated. If it were merely one part of a generated body bearing a relation to another part of the ſame body, as the mouth of an animal to the throat, the throat to the ſtomach, the ſtomach to the inteſtines, thoſe to the recruiting of the blood, and, by means of the blood, to the nouriſhment of the whole frame: or, if it were only one generated body bearing a relation to another generated body, as the ſexes of the ſame ſpecies to each other, animals of prey to their prey, herbivorous and graminivorous animals to the plants or ſeeds upon which they feed, it might be contended, that the whole of this correſpondency was attributable to generation, the common origin from which theſe ſubſtances proceeded. But what ſhall we ſay to agreements which exiſt between things generated and things *not generated?* Can it be doubted, was it ever doubted, but that the *lungs* of animals bear a relation to the *air*, as a permanently elaſtic fluid? They act in it and by it: they cannot act without it. Now, if generation produced the animal, it did not produce the air; yet their properties correſpond. The *eye* is made for *light*, and light 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* depends 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 motions bearing an evident reference to each other: yet the one, and the apparatus for the one, produced by the intervention of generation; the other altogether independent of it.

If it be ſaid, that the air, the light, the elements, the world itſelf, is *generated*, I anſwer, that I do not comprehend the propoſition. If the term mean any thing, ſimilar to what it means, when applied to plants or animals, the propoſition is certainly without proof; and, I think, draws as near to abſurdity, as any propoſition can do, which does not include a contradiction in its terms. I am at a loſs to conceive, how the formation of the world can be compared to the generation of an animal. If the term generation, ſignify ſomething quite different from what it ſignifies upon ordinary occaſions, it may, by the ſame latitude, ſignify any thing. In which caſe a word or phraſe taken from the language of Otaheite, would convey as much theory concerning the origin of the univerſe, as it does to talk of its being generated.

We know a cauſe (intelligence) adequate to the appearances, which we wiſh to account for: we have this cauſe continually producing ſimilar appearances: yet, rejecting this cauſe, the ſufficiency of which we know, and the action of which is conſtantly before our eyes, we are invited to reſort to ſuppoſitions, deſtitute of a ſingle fact for their ſupport, and confirmed by no analogy with which we are acquainted. Were it neceſſary to enquire 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 peurility 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 ſyſtems 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 ſhew the direct impoſſibility of the hypotheſis. In the preſent example, there ſeemed to be a poſitive objection to the whole ſcheme upon the very face of it; which was, that, if the caſe were as here repreſented, *new* combinations 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. For this, however, our philoſopher has an anſwer. Whilſt ſo many forms of plants and animals are already in exiſtence, and, conſequently, ſo many "internal molds," as he calls them, are prepared and at hand, the organic particles run into theſe molds, and are employed in ſupplying an acceſſion of ſubſtance to 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 "molds" 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 deſart 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, the only ſupport on which it reſts, 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 molds, or of vacancies in thoſe molds, 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 acccompanies us to the very limits of our knowledge or enquiries, 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 are found.* Add to this, that their *conſtancy to their ſpecies*, which, I believe, is as regular in theſe as in the other vermes, decides the queſtion againſt our philoſopher, if, in truth, any queſtion remained upon the ſubject.

Laſtly; theſe wonder-working inſtruments, theſe "internal molds," what are they after all? what, when examined, but a name without ſignification; unintelligible, if not ſelf-contradictory; at the beſt, differing nothing from the "eſſential forms" of the Greek philoſophy? One ſhort ſentence of Buffon's work exhibits his ſcheme as follows. "When this nutritious and prolific matter, which is diffuſed throughout all nature, paſſes through the *internal mold* of an animal or vegetable, and finds a proper matrix or receptacle, it gives riſe to an animal or vegetable of the ſame ſpecies." Does any reader annex a meaning to the expreſſion, "internal mold," in this ſentence? Ought it then to be ſaid, that, though we have little notion of an internal mold, we have not much more of a deſigning mind? The very contrary of this aſſertion is the truth. When we ſpeak of an artificer or an architect, we talk of what is comprehenſible to our underſtanding, and familiar to our experience. We uſe no other terms, than what refer us for their meaning to our conſciouſneſs and obſervation; what expreſs the conſtant objects of both: whereas names, like that we have mentioned, refer us to nothing; excite no idea; convey a ſound to the ear, but I think do no more.

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

ANOTHER ſyſtem, which has lately been brought forward, and with much ingenuity, is that of *appetencies.* The principle, and the ſhort account, of the theory, is this. Pieces of ſoft, ductile, matter, being endued with propenſities or appetencies for particular actions, would, by continual endeavours, carried on through a long ſeries of generations, work themſelves gradually into ſuitable forms; and, at length, acquire, though perhaps by obſcure and almoſt imperceptible improvements, an organization fitted to the action which their reſpective propenſities lead them to exert. A piece of animated matter, for example, that was endued with a propenſity to *fly*, though ever ſo ſhapeleſs, though no other, we will ſuppoſe, than a round ball to begin with, would, in a courſe of ages, if not in a million of years, perhaps in a hundred millions of years, (for our theoriſts, having eternity to diſpoſe of, are never ſparing in time,) acquire *wings.* The ſame tendency to loco-motion in an aquatic animal, or rather an animated lump which might happen to be ſurrounded by water, would end in the production of *fins:* in a living ſubſtance, confined to the ſolid earth, would put out *legs* and *feet;* or, if it took a different turn, would break the body into ringlets, and conclude by *crawling* upon the ground.

Although I have introduced the mention of this theory into this place, I am unwilling to give to it the name of an *atheiſtic* ſcheme, for two reaſons; firſt, becauſe, ſo far as I am able to underſtand it, the original propenſities and the numberleſs varieties of them (ſo different, in this reſpect, from the laws of mechanical nature, which are few and ſimple) are, in the plan itſelf, attributed to the ordination and appointment of an intelligent and deſigning Creator: ſecondly, becauſe, likewiſe, that large poſtulatum, which is all along aſſumed and preſuppoſed, the faculty in living bodies of producing other bodies organized like themſelves, ſeems to be referred to the ſame cauſe; at leaſt is not attempted to be accounted for by any other. In one important reſpect, however, the theory before us coincides with atheiſtic ſyſtems, viz. in that, in the formation of plants and animals, in the ſtructure and uſe of their parts, it does away final cauſes. Inſtead of the parts of a plant or animal, or the particular ſtructure of the parts, having been intended for the action or the uſe to which we ſee them applied, according to this theory they have themſelves grown out of that action, ſprung from that uſe. The theory therefore diſpenſes with that which we inſiſt upon, the neceſſity, in each particular caſe, of an intelligent, deſigning, mind, for the contriving and determining of the forms which organized bodies bear. Give our philoſopher theſe appetencies; give him a portion of living irritable matter (a nerve, or the clipping of a nerve,) to work upon; give alſo to his incipient or progreſſive forms, the power, in every ſtage of their alteration, of propagating their like; and, if he is to be believed, he could repleniſh the world with all the vegetable and animal productions which we at preſent 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

* 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

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 alternative 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 gradation, of which no human record 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 alledged are of the following kind. The *bunch* of a camel, is ſaid to be no other than the effect of carrying burthens; 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 grumous tumour to be formed in the fleſh of that part. The next progeny would bring this tumour into the world with them. The life, to which they were deſtined, would increaſe it. The cauſe, which firſt generated the tubercle, being continued, it would go on, through every ſucceſſion, to augment its ſize, till it attained the form and the bulk under which it now appears. This may ſerve for one inſtance: another, and that alſo of the paſſive ſort, is taken from certain ſpecies of birds. Birds of the *crane* kind, as the crane itſelf, the heron, bittern, ſtork, have, in general, their thighs bare of feathers. This privation is accounted for from the habit of wading in water, and from the effect of that element to check the growth of feathers upon theſe parts: in conſequence of which, the health and vegetation of the feathers declined through each generation of the animal: the tender down, expoſed to cold and wet-

be ſome foundation for an opinion, of which I draw the hint from a paper of Mr. Everard Home's (Phil. Tranſac. 1799, p. 2.) viz. that the mammæ of the fœtus may be formed before the ſex is determined.

nefs, became weak, and thin, and rare, till the deterioration ended in the refult which we fee, of abfolute nakednefs. I will mention a third inftance, becaufe it is drawn from an active habit, as the two laft were from paffive habits; and that is the *pouch* of the pelican. The defcription, which naturalifts give of this organ is as follows: "From the lower edges of the under chap, hangs a bag, reaching from the whole length of the bill to the neck, which is faid to be capable of containing fifteen quarts of water. This bag the bird has a power of wrinkling up into the hollow of the under chap. When the bag is empty it is not feen: but when the bird has fifhed with fuccefs, it is incredible to what an extent it is often dilated. The firft thing the pelican does in fifhing, is to fill the bag; and then it returns to digeft its burthen at leifure. The bird preys upon the large fifhes, and hides them by dozens in its pouch. When the bill is opened to its wideft extent, a perfon may run his head into the bird's mouth; and conceal it in this monftrous pouch, thus adapted for very fingular purpofes."* Now this extraordinary conformamation, is nothing more, fay our philofophers, than the refult of habit; not of the habit or effort of a fingle pelican, or of a fingle race of pelicans, but of a habit perpetuated through a long feries of generations. The pelican foon found the conveniency of referving in its mouth, when its appetite was glutted, the remainder of its prey, which is fifh. The fullnefs produced by this attempt, of courfe ftretched the fkin which lies between the under chaps, as being the moft yielding part of the mouth. Every diftenfion increafed the cavity. The original bird, and many generations which fucceeded him, might find difficulty enough in making the pouch anfwer this purpofe: but future pelicans, entering upon life with a

* Goldfmith, vol. vi. p. 52.

pouch derived from their progenitors, of conſiderable capacity, would more readily accelerate its advance to perfection, by frequently preſſing down the ſack with the weight of fiſh which it might now be made to contain.

Theſe, or of this kind, are the analogies relied upon. Now in the firſt place, the inſtances themſelves are unauthenticated by teſtimony; and, in theory, to ſay the leaſt of them, open to great objections. Who ever read of camels without bunches, or with bunches leſs than thoſe with which they are at preſent uſually formed? A bunch, not unlike the camel's, is found between the ſhoulders of the buffalo; of the origin of which it is impoſſible to give the account which is here given. In the ſecond example; Why ſhould the application of water, which appears to promote and thicken the growth of feathers upon the bodies and breaſts of geeſe and ſwans, and other water fowls, have diveſted of this covering the thighs of cranes? The third inſtance, which appears to me as plauſible as any that can be produced, has this againſt it, that it is a ſingularity reſtricted to the ſpecies; whereas, if it had its commencement in the cauſe and manner which have been aſſigned, the like conformation might be expected to take place in other birds, which feed upon fiſh. How comes it to paſs, that the pelican alone was the inventreſs, and her deſcendants the only inheritors, of this curious reſource?

But it is the leſs neceſſary to contravert the inſtances themſelves, as it is a ſtraining of analogy beyond all limits of reaſon and credibility, to aſſert that birds, and beaſts, and fiſh, with all their variety and complexity of organization, have been brought into their forms, and diſtinguiſhed into their ſeveral kinds and natures, by the ſame proceſs (even if that proceſs could be demonſtrated, or had ever been actually noticed) as might ſeem to ſerve for the gradual generation of a camel's bunch, or a pelican's pouch.

The ſolution, when applied to the works of nature *generally*, is contradicted by many of the phænomena, and totally inadequate to others. The *ligaments* or ſtrictures, by which the tendons are tied down at the angles of the joints, could, by no poſſibility, be formed by the motion or exerciſe of the tendons themſelves; by any appetency exciting theſe parts into action; or by any tendency ariſing therefrom. The tendency is all the other way: the conatus in conſtant oppoſition to them. Length of time does not help the caſe at all, but the reverſe. The *valves* alſo in the blood-veſſels, could never be formed in the manner which our theoriſt propoſes. The blood, in its right and natural courſe, has no tendency to form them. When obſtructed or refluent, it has the contrary. Theſe parts could not grow out of their uſe, though they had eternity to grow in.

The *ſenſes* of animals appear to me altogether incapable of receiving the explanation of their origin which this theory affords. Including under the word "ſenſe" the organ and the perception, we have no account of either. How will our philoſopher get at *viſion*, or make an eye? How ſhould the blind animal affect ſight, of which blind animals, we know, have neither conception nor deſire? Affecting it, by what operation of its will, by what endeavor to ſee, could it ſo determine the fluids of its body, as to inchoate the formation of an eye? or, ſuppoſe the eye formed, would the perception follow? The ſame of the other ſenſes. And this objection holds its force, aſcribe what you will to the hand of time, to the power of habit, to changes, too ſlow to be obſerved by man, or brought within any compariſon which he is able to make of paſt things with the preſent: concede what you pleaſe to theſe arbitrary and unatteſted ſuppoſitions, how will they help you? Here is no inception. No laws, no courſe, no powers of nature which prevail at preſent, nor any analogous to theſe, could give commencement to a new ſenſe. And it is in vain to enquire, how that might proceed, which could never *begin*.

I think the ſenſes, to be the moſt inconſiſtent with the hypotheſis before us, of any part of the animal frame. But other parts are ſufficiently ſo. The ſolution does not apply to the parts of animals, which have little in them of motion. If we could ſuppoſe joints and muſcles to be gradually formed by action and exerciſe, what action or exerciſe could form a ſkull, or fill it with brains? No effort of the animal could determine the clothing of its ſkin. What conatus could give prickles to the porcupine or hedgehog, or to the ſheep its fleece?

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

Upon the whole; after all the ſtruggles of a reluctant philoſophy the neceſſary reſort is to a Deity. The marks of *deſign* are too ſtrong to be got over. Deſign muſt have had a deſigner. That deſigner muſt have been a perſon. That perſon is God.

CHAPTER XXIV.

OF THE NATURAL ATTRIBUTES OF THE DEITY.

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

Yet the contemplation of a nature ſo exalted, however ſurely we arrive at the proof of its exiſtence, overwhelms our faculties. The mind feels its powers ſink under the ſubject. One conſequence of which is, that from painful abſtraction the thoughts ſeek relief in ſenſible images. From whence may be deduced the ancient, and almoſt univerſal, propenſity to idolatrous ſubſtitutions. They are the reſources of laboring imagination. Falſe religions uſually fall in with the natural propenſity: true religions, or ſuch as have derived themſelves from the true, reſiſt it.

It is one of the advantages of the revelations which we acknowledge, that, whilſt they reject idolatry with its many pernicious accompaniments, they introduce the Deity to human apprehenſion, under an idea more perſonal, more determinate, more within its compaſs, than the theology of nature can do. And this they do by repreſenting him excluſively under the relation in which he ſtands to ourſelves; and, for the moſt part, under ſome preciſe character, reſulting from that relation, or from the hiſtory of his providences. Which method ſuits the ſpan of our intellects much better, than the univerſality which enters into the idea of God, as deduced from the views of nature. When, therefore, theſe repreſentations are well founded in point of authority, (for all depends upon that,) they afford a condeſcention to the ſtate of our faculties, of which, thoſe, who have reflected moſt upon the ſubject, will be the firſt to acknowledge the want and the value.

Nevertheless, if we be careful to imitate the documents of our religion, by confining our explanations to what concerns ourselves, and do not affect more precision in our ideas than the subject allows of, the several terms, which are employed to denote the attributes of the Deity, may be made, even in natural religion, to bear a sense, consistent with truth and reason, and not surpassing our comprehension.

These terms are, omnipotence, omniscience, omnipresence, eternity, self-existence, necessary existence, spirituality.

"Omnipotence," "omniscience;" infinite power, infinite knowledge, are *superlatives*; expressing our conception of these attributes in the strongest, and most elevated terms, which language supplies. We ascribe power to the Deity under the name of "omnipotence," the strict and correct conclusion being, that a power, which could create such a world as this is, must be, beyond all comparison, greater than any which we experience in ourselves, than any which we observe in other visible agents; greater, also, than any which we can want, for our individual protection and preservation, in the Being upon whom we depend. It is a power likewise, to which we are not authorised by our observation or knowledge, to assign any limits of space or duration.

Very much of the same sort of remark is applicable to the term "omniscience," infinite knowledge, or infinite wisdom. In strictness of language, there is a difference between knowledge and wisdom; wisdom always supposing action, and action directed by it. With respect to the first, viz. knowledge, the Creator must *know*, intimately, the constitution and properties of the things which he created; which seems also to imply a foreknowledge of their action upon one another, and of their changes; at least, so far as the same result from trains of physical and necessary causes. His omniscience also, as far as respects things present, is deducible from his nature, as an intelligent being, joined with the extent, or rather the universality, of his operations. Where he acts, he is; and, where he is, he perceives. The *wisdom* of the Deity, as testified in the works of creation, surpasses all idea we have of wisdom, drawn from the highest intellectual operations of the highest class of intelligent beings with whom we are acquainted; and, which is of the chief importance to us, whatever be its compass or extent, which it is evidently impossible that we should be able to determine, it must be adequate to the conduct of that order of things under which we live. And this is enough. It is of very inferior consequence, by what terms we express our notion, or rather our admiration, of this attribute. The terms, which the piety and the usage of language have rendered habitual to us, may be as proper as any other. We can trace this attribute much beyond what is necessary for any conclusion to which we have occasion to apply it. The degree of knowledge and power, requisite for the formation of created nature, cannot, with respect to us, be distinguished from infinite.

The divine "omnipresence" stands, in natural theology, upon this foundation. In every part and place of the universe, with which we are acquainted, we perceive the exertion of a power, which we believe, mediately or immediately, to proceed from the Deity. For instance; in what part or point of space, that has ever been explored, do we not discover attraction? In what regions, do we not find light? In what accessible portion of our globe, do not we meet with gravity, magnetism, electricity; together with the properties also and powers of organized substances, of vegetable or of animated nature? Nay, further, we may ask, what kingdom is there of nature, what corner of ſpace, in which there is any thing that can be examined by us, where we do not fall upon contrivance and deſign? The only reflection perhaps which ariſes in our minds from this view of the world around us is, that the laws of nature every where prevail; that they are uniform, and univerſal. But what do we mean by the laws of nature, or by any law? Effects are produced by power, not by laws. A law cannot execute itſelf. A law refers us to an agent. Now an agency ſo general, as that we cannot diſcover its abſence, or aſſign the place in which ſome effect of its continued energy is not found, may, in popular language at leaſt, and, perhaps, without much deviation from philoſophical ſtrictneſs, be called univerſal: and, with not quite the ſame, but with no inconſiderable propriety, the perſon or Being, in whom that power reſides, or from whom it is derived, may be taken to be *omnipreſent*. He who upholds all things by his power, may be ſaid to be every where preſent.

This is called a virtual preſence. There is alſo what metaphyſicians denominate an eſſential ubiquity: and which idea the language of ſcripture ſeems to favor: but the former, I think, goes as far as natural theology carries us.

"Eternity," is a negative idea, clothed with a poſitive name. It ſuppoſes, in that to which it is applied, a preſent exiſtence; and is the negation of a beginning, or an end of that exiſtence. As applied to the Deity, it has not been controverted by thoſe who acknowledged a Deity at all. Moſt aſſuredly, there never was a time in which nothing exiſted, becauſe that condition muſt have continued. The univerſal blank muſt have remained; nothing could riſe up out of it; nothing could ever have exiſted ſince; nothing could exiſt now. In ſtrictneſs, however, we have no concern with duration prior to that of the viſible world. Upon this article therefore of theology, it is sufficient to know, that the contriver necessarily existed before the contrivance.

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

"Necessary existence," means demonstrable existence.

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

CHAPTER XXV.

THE UNITY OF THE DEITY.

Of the "unity of the Deity" the proof is, the *uniformity* of plan observable in the universe. The universe itself is a system; each part either depending upon other parts, or being connected with other parts by some common law of motion, or by the presence of some common substance. One principle of gravitation causes a stone to drop towards the earth, and the moon to wheel round it. One law of attraction carries all the different planets about the sun. This philosophers demonstrate. There are also other points

* Bishop Wilkins' Principles of Nat. Rel. p. 106.

of agreement amongſt them, which may be conſidered as marks of the identity of their origin, and of their intelligent author. In all are found the conveniency and ſtability derived from gravitation. They all experience viciſſitudes of days and nights, and changes of ſeaſon. They all, at leaſt Jupiter, Mars, and Venus, have the ſame advantages from their atmoſpheres as we have. In all the planets the axis of rotation are permanent. Nothing is more probable, than that the ſame attracting influence, acting according to the ſame rule, reaches to the fixed ſtars: but, if this be only probable, another thing is certain, viz. that the ſame element of light does. The light from a fixed ſtar affects our eyes in the ſame manner, is refracted and reflected according to the ſame laws, as the light of a candle. The velocity of the light of the fixed ſtars, is alſo the ſame as the velocity of the light of the ſun, reflected from the ſatellites of Jupiter. The heat of the ſun, in kind, differs nothing from the heat of a coal fire.

In our own globe the caſe is clearer. New countries are continually diſcovered, but the old laws of nature are always found in them: new plants perhaps or animals, but always in company with plants and animals, which we already know; and always poſſeſſing many of the ſame general properties. We never get amongſt ſuch original, or totally different, modes of exiſtence, as to indicate, that we are come into the province of a different Creator, or under the direction of a different will. In truth, the ſame order of things attends us, wherever we go. The elements act upon one another, electricity operates, the tides riſe and fall, the magnetic needle elects its poſition, in one region of the earth and ſea, as well as in another. One atmoſphere inveſts all parts of the globe, and connects all: one ſun illuminates; one moon exerts its ſpecific attraction upon all parts. If there be a variety in natural effects, as, e. g. in the tides of different seas, that very variety is the result of the same cause, acting under different circumstances. In many cases this is proved; in all is probable.

The inspection and comparison of *living* forms, add to this argument examples without number. Of all large terrestrial animals the structure is very much alike. Their senses nearly the same. Their natural functions and passions nearly the same. Their viscera nearly the same, both in substance, shape, and office. Digestion, nutrition, circulation, secretion, go on, in a similar manner, in all. The great circulating fluid is the same: for, I think, no difference has been discovered in the properties of *blood*, from whatever animal it be drawn. The experiment of transfusion proves, that the blood of one animal will serve for another. The *skeletons* also of the larger terrestrial animals shew particular varieties, but still under a great general affinity. The resemblance is somewhat less, yet sufficiently evident, between quadrupeds and birds. They are alike in five respects, for one in which they differ.

In *fish*, which belong to another department, as it were, of nature, the points of comparison become fewer. But we never lose sight of our analogy, e. g. we still meet with a stomach, a liver, a spine; with bile and blood; with teeth; with eyes, which eyes are only slightly varied from our own, and which variation, in truth, demonstrates, not an interruption, but a continuance, of the same exquisite plan; for it is the adaptation of the organ to the element, viz. to the different refraction of light passing into the eye out of a denser medium. The provinces, also, themselves of water and earth, are connected by the species of animals which inhabit both; and also by a large tribe of equatic animals, which closely resemble the terrestrial in their internal structure: I mean the cetaceous tribe, which have hot blood, respiring lungs, bowels, and other essential parts, like those of land animals. This similitude, surely, bespeaks the same creation and the same Creator.

Insects and *shell fish* appear to me to differ from other classes of animals the most widely of any. Yet even here, beside many points of particular resemblance, there exists a general relation of a peculiar kind. It is the relation of inversion: the law of contrariety: namely, that, whereas, in other animals, the bones, to which the muscles are attached, lie *within* the body, in insects and shell fish they lie on the *outside* of it. The shell of a lobster performs to the animal the office of a *bone*, by furnishing to the tendons that fixed basis or immoveable fulcrum, without which mechanically they could not act. The crust of an insect is its shell, and answers the like purpose. The shell also of an oyster stands in the place of a *bone;* the bases of the muscles being fixed to it, in the same manner, as, in other animals, they are fixed to the bones. All which (under wonderful varieties, indeed, and adaptations of form) confesses an imitation, a remembrance, a carrying on, of the same plan.

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

Certain however it is, that the whole argument for the divine unity, goes no further than to an unity of counsel.

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

CHAPTER XXVI.

THE GOODNESS OF THE DEITY.

THE proof of the *divine goodness* rests upon two propositions, each, as we contend, capable of being made out by observations drawn from the appearances of nature.

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

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

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

No productions of nature display contrivance so manifestly as the parts of animals: and the parts of animals have all of them, I believe, a real, and, with very few exceptions, all of them a known and intelligible, subserviency to the use of the animal. Now, when the multitude of animals is considered, the number of parts in each, their figure and fitness, the faculties depending upon them, the variety of species, the complexity of structure, the success, in so many cases, and felicity of the result, we can never reflect, without the profoundest adoration, upon the character of that Being from whom all these things have proceeded: we cannot help acknowledging, what an exertion of benevolence creation was; of a benevolence, how minute in its care, how vast in its comprehension.

When we appeal to the parts and faculties of animals, and to the limbs and senses of animals in particular, we state, I conceive, the proper medium of proof for the conclusion which we wish to establish. I will not say, that the insensible parts of nature are made solely for the sensitive parts; but this I say, that, when we consider the benevolence of the Deity, we can only consider it in relation to sensitive Being. Without this reference, or referred to any thing else, the attribute has no object; the term has no meaning. Dead matter is nothing. The parts, therefore, especially the limbs and senses, of animals, although they constitute, in mass and quantity, a small portion of the material creation, yet, since they alone are instruments of perception, they compose what may be called the whole of visible nature, estimated with a view to the disposition of its author. Consequently, it is in these that we are to seek his character. It is by these that we are to prove, that the world was made with a benevolent design.

Nor is the design abortive. It is a happy world after all. The air, the earth, the water, teem with delighted existence. In a spring noon, or a summer evening, on whichever side I turn my eyes, myriads of happy beings crowd upon my view. "The insect youth are on the wing." Swarms of new-born *flies* are trying their pinions in the air. Their sportive motions, their wanton mazes, their gratuitous activity, their continual change of place without use or purpose, testify their joy, and the exultation which they feel in their lately discovered faculties. A *bee* amongst the flowers in spring, is one of the cheerfullest objects that can be looked upon. Its life appears to be all enjoyment: so busy, and so pleased: yet it is only a specimen of insect life, with which, by reason of the animal being half domeſticated, we happen to be better acquainted than we are with that of others. The *whole* winged inſect tribe, it is probable, are equally intent upon their proper employments, and, under every variety of conſtitution, gratified, and perhaps equally gratified, by the offices which the author of their nature has aſſigned to them. But the atmoſphere is not the only ſcene of enjoyment for the inſect race. Plants are covered with aphides, greedily ſucking their juices, and conſtantly, as it ſhould ſeem, in the act of ſucking. It cannot be doubted but that this is a ſtate of intenſe gratification. What elſe ſhould fix them ſo cloſe to their operation, and ſo long? Other ſpecies are *running about* with an alacrity in their motions which carries with it every mark of pleaſure. Large patches of ground are ſometimes half covered with theſe briſk and ſprightly natures. If we look to what the *waters* produce, ſhoals of the fry of fiſh frequent the margins of rivers, of lakes, and of the ſea itſelf. Theſe are ſo happy, that they know not what to do with themſelves. Their attitudes, their vivacity; their leaps out of the water, their frolics in it, (which I have noticed a thouſand times with equal attention and amuſement,) all conduce to ſhew their exceſs of ſpirits, and are ſimply the effects of that exceſs. Walking by the ſea ſide, in a calm evening, upon a ſandy ſhore, and with an ebbing tide, I have frequently remarked the appearance of a dark cloud, or, rather, very thick miſt, hanging over the edge of the water, to the height, perhaps, of half a yard, and of the breadth of two or three yards, ſtretching along the coaſt as far as the eye could reach, and always retiring with the water. When this cloud came to be examined, it proved to be nothing elſe than ſo much ſpace, filled with young *ſhrimps*, in the act of bounding into the air from the ſhallow margin of the water, or from the wet ſand. If any motion of a mute animal could expreſs delight, it was this: if they had meant to make ſigns of their happineſs, they could not have done it more intelligibly. Suppoſe then, what I have no doubt of, each individual of this number to be in a ſtate of poſitive enjoyment, what a ſum, collectively, of gratification and pleaſure have we here before our view!

The *young* of all animals appear to me to receive pleaſure ſimply from the exerciſe of their limbs and bodily faculties, without reference to any end to be attained, or any uſe to be anſwered by the exertion. A child, without knowing any thing of the uſe of language, is, in a high degree, delighted with being able to ſpeak. Its inceſſant repetition of the few articulate ſounds, or, perhaps, of the ſingle word, which it has learnt to pronounce, proves this point clearly. Nor is it leſs pleaſed with its firſt ſucceſsful endeavours to walk, or rather to run, (which precedes walking) although entirely ignorant of the importance of the attainment to its future life: and even without applying it to any preſent purpoſe. A child is delighted with ſpeaking, without having any thing to ſay; and with walking, without knowing where to go. And, prior to both theſe, I am diſpoſed to believe, that the waking hours of infancy are agreeably taken up with the exerciſe of viſion, or perhaps, more properly ſpeaking, with learning to ſee.

But it is not for youth alone, that the great Parent of creation hath provided. Happineſs is found with the purring cat, no leſs than with the playful kitten; in the arm-chair of dozing age, as well as in either the ſprightlineſs of the dance, or the animation of the chace. To novelty, to acuteneſs of ſenſation, to hope, to ardor of purſuit, ſucceeds, what is, in no inconſiderable degree, an equivalent for them all, "perception of eaſe." Herein is the exact difference between the young and the old. The young are not happy, but when enjoying pleaſure ; the old are happy, when free from pain. And this conſtitution ſuits with the degrees of animal power which they reſpectively poſſeſs. The vigor of youth was to be ſtimulated to action by impatience of reſt ; whilſt, to the imbecility of age, quietneſs and repoſe become poſitive gratifications. In one important reſpect the advantage is with the old. A ſtate of eaſe is, generally ſpeaking, more attainable than a ſtate of pleaſure. A conſtitution, therefore, which can enjoy eaſe, is preferable to that which can taſte only pleaſure. This ſame perception of care oftentimes renders old age a condition of great comfort ; eſpecially when riding at its anchor, after a buſy or tempeſtuous life. It is well deſcribed by Rouſſeau, to be the interval of repoſe and enjoyment, between the hurry and the end of life. How far the ſame cauſe extends to other animal natures cannot be judged of with certainty. The appearance of ſatisfaction, with which moſt animals, as their activity ſubſides, ſeek and enjoy reſt, affords reaſon to believe, that this ſource of gratification is appointed to advanced life, under all, or moſt, of its various forms. In the ſpecies with which we are beſt acquainted, namely our own, I am far, even as an obſerver of human life, from thinking, that youth is its happieſt ſeaſon, much leſs the only happy one : as a Chriſtian, I am willing to believe there is a great deal of truth in the following repreſentation, given by a very pious writer, as well as excellent man.* "To the intelligent and virtuous, old age preſents a ſcene of tranquil enjoyments, of obedient appetites, of well regulated affections, of maturity in knowledge, and of calm preparation for immortality. In this ſerene and dignified ſtate, placed, as it were, on the confines of two worlds, the mind of a good man, reviews what is paſt with the complacency of an approving

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

confcience, and looks forward, with humble confidence in the mercy of God, and with devout afpirations towards his eternal and ever increafing favor."

What is feen in different ftages of the fame life, is ftill more exemplified in the lives of different animals. Animal enjoyments are infinitely *diverfified*. The modes of life, to which the organization of different animals refpectively determines them, are not only of various, but of oppofite kinds. Yet each is happy in its own. For inftance; animals of prey, live much alone; animals of a milder conftitution, in fociety. Yet the herring, which lives in fhoals, and the fheep, which lives in flocks, are not more happy in a crowd, or more contented amongft their companions, than is the pike, or the lion, with the deep folitudes of the pool, or the foreft.

But it will be faid, that the inftances which we have here brought forward, whether of vivacity or repofe, or of apparent enjoyment derived from either, are picked and favorable inftances. We anfwer that they are inftances, neverthelefs, which comprife large provinces of fenfitive exiftence; that every cafe which we have defcribed, is the cafe of millions. At this moment, in every given moment of time, how many myriads of animals are eating their food, gratifying their appetites, ruminating in their holes, accomplifhing their wifhes, purfuing their pleafures, taking their paftimes? In each individual how many things muft go right for it to be at eafe; yet how large a proportion out of every fpecies, are fo in every affignable inftant? Secondly, we contend, in the terms of our original propofition, that throughout the whole of life, as it is diffufed in nature, and as far as we are acquainted with it, looking to the average of fenfations, the plurality and the preponderancy is in favor of happinefs by a vaft excefs. In our own fpecies, in which perhaps the affertion may be more questionable than in any other, the prepollency of good over evil, of health, for example, and ease, over pain and distress, is evinced by the very notice which calamities excite. What enquiries does the sickness of our friends produce? What conversation their misfortunes? This shews that the common course of things is in favor of happiness; that happiness is the rule; misery, the exception. Were the order reversed, our attention would be called to examples of health and competency, instead of disease and want.

One great cause of our insensibility to the goodness of the Creator is the very *extensiveness* of his bounty. We prize but little, what we share only in common with the rest, or with the generality, of our species. When we hear of blessings, we think forthwith of successes, of prosperous fortunes, of honors, riches, preferments, i. e. of those advantages and superiorities over others, which we happen either to possess, or to be in pursuit of, or to covet. The common benefits of our nature entirely escape us. Yet these are the great things. These constitute, what most properly ought to be accounted blessings of Providence; what alone, if we might so speak, are worthy of its care. Nightly rest and daily bread, the ordinary use of our limbs, and senses, and understandings, are gifts which admit of no comparison with any other. Yet, because almost every man we meet with possesses these, we leave them out of our enumeration. They raise no sentiment: they move no gratitude. Now, herein, is our judgment perverted by our selfishness. A blessing ought in truth to be the *more* satisfactory, the bounty at least of the doner is rendered more conspicuous, by its very diffusion, its commonness, its cheapness; by its falling to the lot, and forming the happiness, of the great bulk and body of our species, as well as of ourselves. Nay even when we do not poſſeſs it, it ought to be matter of thankfulneſs that others do. But we have a different way of thinking. We court diſtinction. That I don't quarrel with: but we can *ſee* nothing but what has diſtinction to recommend it. This neceſſarily contracts our view of the Creator's beneficence within a narrow compaſs; and moſt unjuſtly. It is in thoſe things which are ſo common as to be no diſtinction, that the amplitude of the divine benignity is perceived.

But pain, no doubt, and privations, exiſt, in numerous inſtances, and to a degree, which, collectively, would be very great, if they were compared with any other thing than with the maſs of animal fruition. For the application, therefore, of our propoſition to that *mixed* ſtate of things which theſe exceptions induce, two rules are neceſſary, and both, I think, juſt and fair rules. One is, that we regard thoſe effects alone which are accompanied with proofs of intention: The other, that, when we cannot reſolve all appearances into benevolence of deſign, we make the few give place to the many; the little to the great; that we take our judgment from a large and decided preponderancy, 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 he wiſhed their happineſs, or he wiſhed their miſery, or he was indifferent and unconcerned about either.

"If he had wiſhed our miſery, he might have made ſure of his purpoſe, by forming our ſenſes to be ſo many ſores and pains to us, as they are now inſtruments of gratification and enjoyment; or by placing us amidſt objects, ſo ill ſuited to our preceptions, as to have continually offended us, inſtead of miniſtering to our refreſhment and delight. He might have made, for example, every thing we taſted bitter; every thing we faw loathfome; every thing we touched a fting; every fmell a ftench; and every found a difcord.

"If he had been indifferent about our happinefs or mifery, we muft impute to our good fortune (as all defign by this fuppofition is excluded) both the capacity of our fenfes to receive pleafure, and the fupply of external objects fitted to produce it.

"But either of thefe, and ftill more both of them, being too much to be attributed to accident, nothing remains but the firft fuppofition, that God, when he created the human fpecies, wifhed their happinefs; and made for them the provifion which he has made, with that view, and for that purpofe.

"The fame argument may be propofed in different terms, thus: Contrivance proves defign; and the predominant tendency of the contrivance indicates the difpofition of the defigner. The world abounds with contrivances; and all the contrivances which we are acquainted with, are directed to beneficial purpofes. Evil no doubt exifts; but is never, that we can perceive, the object of contrivance. Teeth are contrived to eat, not to ache; their aching now and then is incidental to the contrivance, perhaps infeparable from it: or even, if you will, let it be called a defect in the contrivance; but it is not the object of it. This is a diftinction which well deferves to be attended to. In defcribing implements of hufbandry, you would hardly fay of the fickle, that it was made to cut the reaper's hand, though, from the conftruction of the inftrument, and the manner of ufing it, this mifchief often follows. But if you had occafion to defcribe inftruments of torture or execution, This engine, you would fay, is to extend the finews; this to diflocate the joints; this to break the bones; this to fcorch the foles of the feet. Here pain and mifery are the very objects of the contrivance. Now, nothing of this sort is to be found in the works of nature. We never discover a train of contrivance to bring about an evil purpose. No anatomist ever discovered a system of organization, calculated to produce pain and disease; or, in explaining the parts of the human body, ever said, This is to irritate; this to inflame; this duct is to convey the gravel to the kidneys; this gland to secrete the humour which forms the gout: if by chance he come at a part of which he knows not the use, the most that he can say is, that it is useless; no one ever suspects that it is put there to incommode, to annoy, or to torment."

The two cases which appear to me to have the most of difficulty in them, as forming the most of the appearance 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 œconomy 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, directed to ends of undiſputed utility. Of the vindications, however, of this œconomy, which we are able to aſſign, ſuch as moſt extenuate the difficulty, are the following.

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

1. That, the animal itſelf being regarded, the faculty complained of is *good;* being conducive, in all caſes, to the defence of the animal; in ſome caſes, to the ſubduing of its prey; and, in ſome probably, to the killing of it, when caught, by a mortal wound inflicted in the paſſage to the ſtomach, which may be no leſs merciful to the victim, than ſalutary to the devourer. In the viper, for inſtance, the poiſonous fang may do that, which in other animals of prey, is done by the cruſh of the teeth. Frogs and mice might be ſwallowed alive without it.

2. But it will be ſaid, that this proviſion, when it comes to the caſe of bites, deadly even to human bodies and to thoſe of large quadrupeds, is greatly *overdone*; that it might have fulfilled its uſe, and yet have been much leſs deleterious than it is. Now I believe the caſe of bites, which produce death in large animals, (of ſtings I think there are none) to be very few. The experiments of the

Abbe Fontana, which were numerous, go ſtrongly to the proof of this point. He found that it required the action of five exaſperated vipers to kill a dog of a a moderate ſize; but that, to the killing of a mouſe or a frog, a ſingle bite was ſufficient; which agrees with the uſe which we aſſign to the faculty. The Abbe ſeemed to be of opinion, that the bite even of the rattleſnake would not uſually be mortal; allowing, however, that in certain particularly unfortunate caſes, as when the puncture had touched ſome very tender part, pricked a principal nerve for inſtance, or, as it is ſaid, ſome more conſiderable lymphatic veſſel, death might ſpeedily enſue.

3. It has been, I think, very juſtly remarked concerning ſerpents, that, whilſt only a few ſpecies poſſeſs the venomous property, that property guards the whole tribe. The moſt innocuous ſnake is avoided with as much care as a viper. Now the terror, with which large animals regard this claſs of reptiles, is its protection; and this terror is founded in the formidable revenge, which a few of the number, compared with the whole, are capable of taking. The ſpecies of ſerpents, deſcribed by Linnæus, amount to two hundred and eighteen, of which thirty two only are poiſonous.

4. It ſeems to me, that animal conſtitutions are provided, not only for each element, but for each ſtate of the elements, i. e. for every climate, and for every temperature; and that part of the miſchief complained of, ariſes from animals (the human animal moſt eſpecially) occupying ſituations upon the earth which do not belong to them, nor were ever intended for their habitation. The folly and wickedneſs of mankind, and neceſſities proceeding from theſe cauſes, have driven multitudes of the ſpecies to ſeek a refuge amongſt burning ſands, whilſt countries bleſſed with hoſpitable ſkies, and with the moſt fer-

tile soils, remain almost without a human tenant. We invade the territories of wild beasts and venomous reptiles, and then complain that we are infested by their bites and stings. Some accounts of Africa place this observation in a strong point of view. "The desarts," says Adanson, "are entirely barren, except where they are found to produce serpents; and in such quantities, that some extensive plains are almost entirely covered with them." These are the natures appropriated to the situation. Let them enjoy their existence: let them have their country. Surface enough will be left to man, though his numbers were increased an hundred fold, and left to him, where he might live, exempt from these annoyances.

The *second* case, viz. that of animals *devouring* one another, furnishes a consideration of much larger extent. To judge whether, as a general provision, this can be deemed an *evil*, even so far as we understand its consequences, which, probably, is a partial understanding, the following reflections are fit to be attended to.

1. Immortality upon this earth is out of the question. Without death there could be no generation, no sexes, no parental relation, i. e. as things are constituted, no animal happiness. The particular duration of life, assigned to different animals, can form no part of the objection; because, whatever that duration was, whilst it remained finite and limited, it might always be asked, why it was no longer. The natural age of different animals varies from a single day to a century of years. No account can be given of this; nor could any be given, whatever other proportion of life had obtained amongst them.

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

Now, according to the eſtabliſhed order of nature, (which we muſt ſuppoſe to prevail, or we cannot reaſon at all upon the ſubject,) the three methods by which life is uſually put an end to, are acute diſeaſes, decay, and violence. The ſimple and natural life of *brutes*, is not often viſited by acute diſtempers; nor could it be deemed an improvement of their lot, if they were. Let it be conſidered, therefore, in what a condition of ſuffering and miſery a brute animal is placed, which is left to periſh by *decay*. In human ſickneſs or infirmity, there is the aſſiſtance of man's rational fellow creatures, if not to alleviate his pains, at leaſt to miniſter to his neceſſities, and to ſupply the place of his own activity. A brute, in his wild and natural ſtate, does every thing for himſelf. When his ſtrength therefore, or his ſpeed, or his limbs, or his ſenſes fail him, he is delivered over, either to abſolute famine, or to the protracted wretchedneſs of a life ſlowly waſted by ſcarcity of food. Is it then to ſee the world filled with drooping, ſuperannuated, half ſtarved, helpleſs and unhelped animals, that you would alter the preſent ſyſtem of purſuit and prey?

2. Which ſyſtem is alſo to them the ſpring of motion and activity on both ſides. The purſuit of its prey, forms the employment, and appears to conſtitute the pleaſure, of a conſiderable part of the animal creation. The uſing of the means of defence, or flight, or precaution, forms alſo the buſineſs of another part. And even of this latter tribe, we have no reaſon to ſuppoſe, that their happineſs is much moleſted by their fears. Their danger exiſts continually; and in ſome caſes they ſeem to be ſo far ſenſible of it, as to provide, in the beſt manner they can, againſt it; but it is only when the attack is actually made upon them, that they appear to ſuffer from it. To contemplate the inſecurity of their condition with anxiety and dread, requires a degree of reflection,

which (happily for themselves) they do not possess. A *hare*, notwithstanding the number of its dangers and its enemies, is as playful an animal as any other.

3. But, to do justice to the question, the system of animal *destruction* ought always to be considered in strict connexion with another property of animal nature, viz. *superfecundity*. They are countervailing qualities. One subsists by the correction of the other. In treating, therefore, of the subject under this view, (which is, I believe, the true one,) our business will be, first, to point out the advantages which are gained by the powers in nature of a superabundant multiplication; and, then, to shew, that these advantages are so many reasons for appointing that system of animal hostilities, which we are endeavouring to account for.

In almost all cases nature produces her supplies with profusion. A single cod fish spawns, in one season, a greater number of eggs, than all the inhabitants of England amount to. A thousand other instances of prolific generation might be stated, which, though not equal to this, would carry on the increase of the species 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 the world always full; whilst, secondly, it allows the proportion between the several species of animals to be differently modified, as different purposes require, or as different situations may afford for them room and food. Where this vast fecundity meets with a vacancy fitted to receive the species, there it operates with its whole effect; there it pours in its numbers, and replenishes the waste. We complain of what we call the exorbitant multiplication of some troublesome insects, not reflecting that large portions of nature might be left void without it. If the accounts of travellers may be depended upon, immenſe tracts of foreſt in North America would be nearly loſt to ſenſitive exiſtence if it were not for *gnats.* "In the thinly inhabited regions of America, in which the waters ſtagnate, and the climate is warm, the whole air is filled with crowds of theſe inſects." Thus it is, that, where we looked for ſolitude and death-like ſilence, we meet with animation, activity, enjoyment; with a buſy, a happy, and a peopled world. Again; hoſts of *mice* are reckoned amongſt the plagues of the north-eaſt part of Europe; whereas vaſt plains in Siberia, as we learn from good authority, would be lifeleſs without them. The Caſpian deſarts are converted by their preſence into crowded warrens. Between the Volga and the Yaik, and in the country of Hyrcania, the ground, ſays Pallas, is in many places *covered* with little hills, raiſed by the earth caſt out in forming the burrows. Do we then ſo envy theſe bliſsful abodes, as to pronounce the fecundity by which they are ſupplied with inhabitants, to be an evil; a ſubject of complaint, and not of praiſe? Further; by virtue of this ſame ſuperfecundity, what we term deſtruction, becomes almoſt inſtantly the parent of life. What we call blights, are, oftentimes, legions of animated beings claiming their portion in the bounty of nature. What corrupts the produce of the earth to us, prepares it for them. And it is by means of their rapid multiplication, that they take poſſeſſion of their paſture: a ſlow propagation would not meet the opportunity.

But in conjunction with the occaſional uſe of this fruitfulneſs, we obſerve, alſo, that it allows the proportion between the ſeveral ſpecies of animals to be differently modified, as different purpoſes of utility may require. When the foreſts of America come to be cleared, and the ſwamps drained, our gnats will give place to other inhabitants. If the population of Europe ſhould ſpread to the north and the eaſt, the mice will retire before the husbandman and the shepherd, and yield their station to herds and flocks. In what concerns the human species, it may be a part of the scheme of Providence that the earth should be inhabited by a shifting, or perhaps a circulating population. In this œconomy it is possible that there may be the following advantages. When old countries are become exceedingly corrupt, simpler modes of life, purer morals, and better institutions may rise up in new ones, whilst fresh soils reward the cultivator with more plentiful returns. Thus the different portions of the globe come into use in succession as the residence of man; and, in his absence, entertain other guests, which, by their rapid multiplication, soon fill the chasm. In domesticated animals we find the effect of their fecundity to be, that we can always command *numbers*: we can always have as many of any particular species as we please, or as we can support. Nor do we complain of its excess; it being much more easy to regulate abundance, than to supply scarcity.

But then this *superfecundity*, though of great occasional use and importance, exceeds the ordinary capacity of nature to receive or support its progeny. All superabundance supposes destruction, or must destroy itself. Perhaps there is no species of terrestrial animals whatever, which would not overrun the earth, if it were permitted to multiply in perfect safety; or of fish, which would not fill the ocean: at least, if any single species were left to their natural increase without disturbance or restraint, the food of other species would be exhausted by their maintenance. It is necessary, therefore, that the effects of such prolific faculties be curtailed. In conjunction with other checks and limits, all subservient to the same purpose, are the thinnings which take place among animals, by their action upon one another. In some instances we ourſelves experience, very directly, the uſe of theſe hoſtilities. One ſpecies of inſects rids us of another ſpecies; or reduces their ranks. A third ſpecies perhaps keeps the ſecond within bounds: and birds or lizards are a fence againſt the inordinate increaſe by which even theſe laſt might infeſt us. In other, more numerous, and poſſibly more important inſtances, this diſpoſition of things, although leſs neceſſary or uſeful to us, and of courſe leſs obſerved by us, may be neceſſary and uſeful to certain other ſpecies; or even for the preventing of the loſs of certain ſpecies from the univerſe: a misfortune which ſeems to be ſtudiouſly guarded againſt. Though there may be the appearance of failure in ſome of the details of Nature's works, in her great purpoſes there never are. Her ſpecies never fail. The proviſion which was originally made for continuing the repleniſhment of the world has proved itſelf to be effectual through a long ſucceſſion of ages.

What further ſhews, that the ſyſtem of deſtruction amongſt animals holds an expreſs relation to the ſyſtem of fecundity; that they are parts indeed of one compenſatory ſcheme; is, that, in each ſpecies, the fecundity bears a proportion to the ſmallneſs of the animal, to the weakneſs, to the ſhortneſs of its natural term of life, and to the dangers and enemies by which it is ſurrounded. An elephant produces but one calf: a butterfly lays ſix hundred eggs. Birds of prey ſeldom produce more than two eggs: the ſparrow tribe, and the duck tribe, frequently ſit upon a dozen. In the rivers, we meet with a thouſand minnows for one pike; in the ſea, a million of herrings for a ſingle ſhark. Compenſation obtains throughout. Defenceleſsneſs and devaſtation are repaired by fecundity.

We have dwelt the longer upon theſe conſiderations, becauſe the ſubject to which they apply, namely, that of animals *devouring* one another, forms the chief, if not the only inſtance, in the works of the Deity, of an œconomy, ſtamped by marks of deſign, in which the character of utility can be called in queſtion. The caſe of *venomous* animals is of much inferior conſequence to the caſe of prey, and, in ſome degree, is alſo included under it. To both caſes it is probable that many more reaſons belong, than thoſe of which we are in poſſeſſion.

Our *firſt* propoſition, and that which we have hitherto been defending, was, "that in a vaſt plurality of inſtances, in which *contrivance* is perceived, the deſign of the contrivance is beneficial."

Our *ſecond* propoſition is, "that the Deity has added *pleaſure* to animal ſenſations, beyond what was neceſſary for any other purpoſe, or when the purpoſe, ſo far as it was neceſſary, might have been effected by the operation of pain."

This propoſition may be thus explained. The capacities, which, according to the eſtabliſhed courſe of nature, are *neceſſary* to the ſupport or preſervation of an animal, however manifeſtly they may be the reſult of an organization contrived for the purpoſe, can only be deemed an act, or a part of the ſame will, as that which decreed the exiſtence of the animal itſelf; becauſe, whether the creation proceeded from a benevolent or a malevolent being, theſe capacities muſt have been given, if the animal exiſted at all. Animal properties therefore, which fall under this deſcription, do not ſtrictly prove the goodneſs of God. They may prove the exiſtence of the Deity: they may prove a high degree of power and intelligence: but they do not prove his goodneſs; foraſmuch as they muſt have been found in any creation which was capable of continuance, although it is poſſible to ſuppoſe, that ſuch a creation might have been produced by a being whoſe views reſted upon miſery.

But there is a claſs of properties, which may be ſaid to be ſuperadded from an intention expreſsly directed to happineſs; an intention to give a happy exiſtence diſtinct from the general intention of providing the means of exiſtence; and that is, of capacities for pleaſure, in caſes, wherein, ſo far as the converſation of the individual or of the ſpecies is concerned, they were not wanted, or wherein, the purpoſe might have been ſecured by the operation of pain. The proviſion which is made of a variety of objects, not neceſſary to life, and miniſtering only to our pleaſures; and the properties given to the neceſſaries of life themſelves, by which they contribute to pleaſure as well as preſervation; ſhew a further deſign, than that of giving exiſtence.*

A ſingle inſtance will make all this clear. Aſſuming the neceſſity of food for the ſupport of animal life, it is requiſite, that the animal be provided with organs, fitted for the procuring, receiving, and digeſting of its food. It may alſo be neceſſary, that the animal be impelled by its ſenſations to exert its organs. But the pain of hunger would do all this. Why add pleaſure to the act of eating; ſweetneſs and reliſh to food? Why a new and appropriate ſenſe for the perception of pleaſure? Why ſhould the juice of a peach applied to the palate, affect the part ſo differently from what it does when rubbed upon the palm of the hand? This is a conſtitution, which, ſo far as appears to me, can be reſolved into nothing but the pure benevolence of the Creator. Eating is neceſſary; but the pleaſure attending it is not neceſſary: and that this pleaſure, depends not only upon our being in poſſeſſion of the ſenſe of taſte, which is different from every other, but upon a particular ſtate of the organ in which it reſides, a

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

felicitous adaptation of the organ to the object, will be confessed by any one, who may happen to have experienced that vitiation of taste which frequently occurs in fevers, when every taste is irregular, and every one bad.

In mentioning the gratifications of the palate, it may be said that we have made choice of a trifling example. I am not of that opinion. They afford a share of enjoyment to man; but to brutes, I believe, that they are of very great importance. A horse at liberty passes a great part of his waking hours in eating. To the ox, the sheep, the deer, and other ruminating animals, the pleasure is doubled. Their whole time almost is divided between browsing upon their pasture and chewing their cud. Whatever the pleasure be, it is spread over a large portion of their existence. If there be animals, such as the lupous fish, which swallow 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 that the seat of taste with them is in the stomach; or, at least, that a sense of pleasure, whether it be taste or not, accompanies the dissolution of the food in that receptacle, which dissolution in general is carried on very slowly? If this opinion be right, they are more than repaid for their defect of palate. The feast lasts as long as the digestion.

In seeking for argument we need not stay to insist upon the comparative importance of our example, for the observation holds equally of all, or of three at least, of the other senses. The necessary purposes of hearing might have been answered without harmony; of smell, without fragrance; of vision, without beauty. Now "If the Deity had been indifferent about our happiness or misery, we must impute to our good fortune (as all design by this supposition is excluded) both the capacity of our senses to receive pleasure, and the ſupply of external objects fitted to excite it." I alledge theſe as *two* felicities, for they are different things, yet both neceſſary; the ſenſe being formed, the objects, which were applied to it, might not have ſuited it; the objects being fixed, the ſenſe might not have agreed with them. A coincidence is here required which no accident can account for. There are three poſſible ſuppoſitions upon the ſubject, and no more. The firſt; that the ſenſe, by its original conſtitution, ſuited the object: the ſecond; that the object, by its original conſtitution, ſuited the ſenſe: the third; that the ſenſe is ſo conſtituted, as to be able, either univerſally, or within certain limits, by habit and familiarity, 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 were conferred upon the objects that ſurround us, not only choice and ſelection, out of 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 dullneſs 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 dullneſs 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 elder; nor will that which we find upon fennel, touch the roſe buſh. Some inſects confine themſelves to two or three kinds of plants or animals. Some again ſhew ſo ſtrong a preference, as to afford reaſon to believe that, though they may be driven by hunger to others, they are led by the pleaſure of taſte to a few particular plants alone; and all this, as it ſhould ſeem, independently of habit or imitation.

But ſhould we accept the third hypotheſis, and even carry it ſo far, as to aſcribe every thing, which concerns the queſtion, to habit, (as in certain ſpecies, the human ſpecies moſt particularly, there is reaſon to attribute ſomething) we have then before us an animal capacity, not leſs perhaps to be admired, than the native congruities which the other ſcheme adopts. It cannot be ſhewn to reſult from any fixed neceſſity in nature, that what is frequently applied to the ſenſes ſhould of courſe become agreeable to them. It is, ſo far as it ſubſiſts, a power of accommodation conſidered and provided by the author of their ſtructure, and forms a part of their perfection.

In whichever way we conſider the ſenſes, they appear to be ſpecific gifts, miniſtering, not only to preſervation, but to pleaſure. But what we uſually call the *ſenſes* are probably themſelves far from being the only vehicles of enjoyment, or the whole of our conſtitution, which is calculated for the ſame purpoſe. We have many internal ſenſations of the moſt agreeable kind, hardly referable to any of the five ſenſes.

Some physiologists have held, that all secretion is pleasurable; and that the complacency which in health, without any external, assignable, object to excite it, we derive from life itself, is the effect of our secretions going on well within us. All this may be true: but, if true, what reason can be assigned for it, except the will of the Creator? It may reasonably be asked, Why is any thing a pleasure? and I know no answer which can be returned to the question, but that which refers it to appointment. We can give no account whatever of our pleasures in the simple and original perception; and, even when physical sensations are assumed, we can seldom account for them in the secondary and complicated shapes, in which they take the name of diversions. I never yet met with a sportsman, who could tell me in what the sport consisted; who could resolve it into its principle, and state that principle. I have been a great follower of fishing myself, and in its chearful solitude have passed some of the happiest hours of a sufficient happy life; but, to this moment, I could never trace out the source of the pleasure which it afforded me.

The "quantum in rebus inane," whether applied to our amusements, or to our graver pursuits, (to which, in truth, it sometimes equally belongs,) is always an unjust complaint. If trifles engage, and if trifles make us happy, the true reflection suggested by the experiment, is upon the tendency of nature to gratification and enjoyment; which is, in other words, the goodness of its author towards his sensitive creation.

Rational natures also, as such, exhibit qualities which help to confirm the truth of our position. The degree of understanding found in mankind, is usually much greater than what is necessary for preservation. The pleasure of choosing for themselves, and of prosecuting the object of their choice, should seem to be an original source of enjoyment. The pleasures received from things great, beautiful, or new, from imitation, or from the liberal arts, are, in fome meafure, not only fuperadded, but unmixed gratification, having no pains to balance them.*

I do not know whether our attachment to *property* be not fomething more than the mere dictate of reafon, or even than the mere effect of affociation. Property communicates a charm to whatever is the object of it. It is the firft of our abftract ideas; it cleaves to us the clofeft and the longeft. It endears to the child its plaything, to the peafant his cottage, to the landholder his eftate. It fupplies the place of profpect and fcenery. Inftead of coveting the beauty of diftant fituations, it teaches every man to find it in his own. It gives boldnefs and grandeur to plains and fens, tinge and colouring to clays and fallows.

All thefe confiderations come in aid of our *fecond* propofition. The reader will now bear in mind what our *two* propofitions were. They were, firft; that, in a vaft plurality of inftances, in which contrivance is perceived, the defign of the contrivance is beneficial: fecondly; that the Deity has added pleafure to animal fenfations beyond what was neceffary for any other purpofe; or when the purpofe, fo far as it was neceffary, might have been effected by the operation of pain.

Whilft thefe propofitions can be maintained, we are authorized to afcribe to the Deity the character of benevolence: and what is benevolence at all, muft in him be *infinite* benevolence, by reafon of the infinite, that is to fay, the incalculably great number of objects, upon which it is exercifed.

Of the ORIGIN OF EVIL no univerfal folution has been difcovered: I mean no folution which reaches to all cafes of complaint. The moft com-

* Balguy on the Divine Benevolence.

prehenſive 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 our conduct. The conſervation of them may be of importance in other reſpects, or to other beings, but we are uninformed of their value or uſe: conſequently when, and how far, they may or may not be ſuſpended, or their effects turned aſide, by a preſiding and benevolent will, without incurring greater evils than thoſe which would be avoided. The conſideration, therefore, of general laws, although it may concern the queſtion of the origin of evil very nearly, (which I think it does,) reſts in views diſproportionate to our faculties, and in a knowledge which we do not poſſeſs. It ſerves rather to account for the obſcurity of the ſubject, than to ſupply us with diſtinct anſwers to our difficulties. However, whilſt we aſſent to the above ſtated propoſitions as principles, whatever uncertainty we may find in the application, we lay a ground for believing, that caſes, of apparent evil, for which *we* can ſuggeſt no particular reaſon, are governed by reaſons, which are more general, which lie deeper in the order of ſecond cauſes, and on that account are removed to a greater diſtance from us.

The doctrine of *imperfections*, or, as it is called, of evils of imperfection, furniſhes an account, founded like the former, in views of univerſal nature. The doctrine is briefly this. It is probable that creation may be better repleniſhed, by ſenſative beings of different ſorts, than by ſenſative beings all of one ſort. It is likewiſe probable, that it may be better repleniſhed, by different orders of being riſing one above another in gradation, than by beings poſſeſſed of equal degrees 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 a 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 authorised 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 endeavours 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 have 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 ſhews the uſe of pain, and that we ſtand in need of ſuch a monitor. I believe alſo that the uſe extends further 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 pain, but by the high degree of comfort which they derive from its ceſſation, whenever that occurs: and which they taſte with a reliſh, that diffuses some portion of mental complacency over the whole of that mixed state of sensations in which disease has placed them.

In connexion with bodily pain may be considered bodily *disease*, whether painful or not. Few diseases are fatal. I have before me the account of a dispensary in the neighbourhood, which states six years experience as follows: "admitted 6,420—*cured* 5,476—dead 234." And this I suppose nearly to agree with what other similar institutions exhibit. Now, in all these cases, some disorder must have been felt, or the patients would not have applied for a remedy; yet we see how large a proportion of the maladies which were brought forward, have either yielded to proper treatment, or, what is more probable, ceased of their own accord. We owe these frequent recoveries, and, where recovery does not take place, this patience of the human constitution under many of the distempers by which it is visited, to two benefactions of our nature. One is, that she works within certain limits; allows of a certain latitude, within which health may be preserved, and within the confines of which it only suffers a graduated diminution. Different quantities of food, different degrees of exercise, different portions of sleep, different states of the atmosphere, are compatible with the possession of health. So likewise is it 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 endeavour to restore itself, when disordered, to its regular course. The fluids of the body appear to possess a power of separating and expelling any noxious substance which 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, with the heart-ſinking diſmay with which he ſhould ſome time ago have met it in health. There is no ſimilitude between the ſenſations of a man led to execution, and the calm expiring of a patient at the cloſe of his diſeaſe. Death to him is only the laſt of a long train of changes: in his progreſs through which, it is poſſible that he may experience no ſhocks or ſudden tranſitions.

Death itſelf, as a mode of removal and of ſucceſſion, is ſo connected with the whole order of our animal world, that almoſt every thing in that world muſt be changed, to be able to do without it. It may ſeem likewiſe impoſſible to ſeparate the fear of death from the enjoyment of life, or the perception of that fear from rational natures. Brutes are in a great meaſure delivered from all anxiety on this account by the inferiority of their faculties; or rather they ſeem to be armed with the apprehenſion of death juſt ſufficiently to put them upon the means of preservation, and no further. But would a human being wish to purchase this immunity by the loss of those mental powers which enable him to look forward to the future?

Death implies *separation*: and the loss of those whom we love must necessarily be accompanied with pain. To the brute creation, nature seems to have stepped in with some secret provision for their relief, under the rupture of their attachments. In their instincts towards their offspring, and of their offspring to them, I have often been surprised to observe, how ardently they love, and how soon they forget. The pertinacity of human sorrow (upon which time also, at length, lays its softening hand) is probably, therefore, in some manner connected with the qualities of our rational or moral nature. One thing however is clear, viz. that it is better that we should possess affections, the sources of so many virtues and so many joys, although they be exposed to the incidents of life, as well as the interruptions of mortality, than, by the want of them, be reduced to a state of selfishness, apathy, and quietism.

Of other external evils (still confining ourselves to what are called physical or natural evils) a considerable part come within the scope of the following observation. The great principle of human satisfaction is *engagement*. It is a most just distinction, which the late Mr. Tucker has dwelt upon so largely in his works, between pleasures in which we are passive, and pleasures in which we are active. And, I believe, every attentive observer of human life will assent to his position, that, however grateful the sensations may occasionally be in which we are passive, it is not these, but the latter class of our pleasures, which constitute satisfaction; which supply that regular stream of moderate and miscellaneous enjoyments, in which happiness, as distinguished from voluptuoufnefs, confifts. Now for rational occupation, which is, in other words, for the very material of contented exiftence, there would be no place left, if either the things with which we had to do were abfolutely impracticable to our endeavours, or if they were too obedient to our ufes. A world furnifhed with advantages on one fide, and befet with difficulties, wants, and inconveniences on the other, is the proper abode of free, rational, and active natures, being the fitteft to ftimulate and exercife their faculties. The very *refractorinefs* of the objects they have to deal with contributes to this purpofe. A world in which nothing depended upon ourfelves, however it might have fuited an imaginary race of beings, would not have fuited mankind. Their fkill, prudence, induftry; their various arts, and their beft attainments, from the application of which they draw, if not their higheft, their moft permanent gratifications, would be infignificant, if things could be either molded by our volitions, or, of their own accord, conformed themfelves to our views and wifhes. Now it is in this refractorinefs that we difcern the feed and principle of *phyfical* evil, as far as it arifes from that which is external to us.

Civil evils, or the evils of civil life, are much more eafily difpofed of than phyfical evils; becaufe they are, in truth, of much lefs magnitude, and alfo becaufe they refult by a kind of neceffity, not only from the conftitution of our nature, but from a part of that conftitution which no one would wifh to fee altered. The cafe is this. Mankind will in every country *breed up* to a certain point of diftrefs. That point may be different in different countries or ages according to the eftablifhed ufages of life in each. It will alfo fhift upon the fcale, fo as to admit of a greater or lefs number of inhabitants, as the quantity of provifion which is either produced in the country or supplied to it from others may happen to vary. But there must always be such a point, and the species will always breed up to it. The order of generation proceeds by something like a geometrical progression. The increase of provision, under circumstances even the most advantageous, can only assume the form of an arithmetic series. Whence it follows, that the population will always overtake the provision, will pass beyond the line of plenty, and will continue to increase till checked by the difficulty of procuring subsistence.* Such difficulty therefore, along with its attendant circumstances, *must* be found in every old country; and these circumstances constitute what we call poverty, which necessarily imposes labour, servitude, restraint.

It seems impossible to people a country with inhabitants who shall be all in easy circumstances. For suppose the thing to be done, there would be such marrying and giving in marriage amongst them, as would in a few years change the face of affairs entirely; i. e. as would increase the consumption of those articles, which supplied the natural or habitual wants of the country, to such a degree of scarcity, as must leave the greatest part of the inhabitants unable to procure them without toilsome endeavours, or out of the different kinds of these articles, to procure any kind except that which was most easily produced. And this, in fact, describes the condition of the mass of the community in all countries; a condition, unavoidably, as it should seem, resulting from the provision which is made in the human, in common with all animal constitutions, for the perpetuity and multiplication of the species.

It need not however dishearten any endeavors for

* See this subject stated in a late treatise upon population.

the public ſervice, to know that population naturally treads upon the heels of improvement. If the condition of a people be meliorated, the conſequence will be, either that the *mean* happineſs will be increaſed, or a greater number partake of it; or, which is moſt likely to happen, that both effects will take place together. There may be limits fixed by nature to both, but they are limits not yet attained, nor even approached, in any country of the world.

And when we ſpeak of limits at all, we have reſpect only to proviſions for animal wants. There are ſources, and means, and auxiliaries, and augmentations of human happineſs, communicable without reſtriction of numbers; as capable of being poſſeſſed by a thouſand perſons, as by one. Such are thoſe, which flow from a mild, contraſted with a tyrannic government, whether civil or domeſtic; thoſe which ſpring from religion; thoſe which grow out of a ſenſe of ſecurity; thoſe which depend upon habits of virtue, ſobriety, moderation, order; thoſe, laſtly, which are founded in the poſſeſſion of well directed taſtes and deſires, compared with the dominion of tormenting, pernicious, contradictory, unſatisfied, and unſatisfiable paſſions.

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

In the firſt place the advantages which the higher conditions of life are ſuppoſed to confer, bear no proportion in value to the advantages which are beſtowed by nature. The gifts of nature always ſurpaſs the gifts of fortune. How much, for example, is activity better than attendance; beauty, than dreſs; appetite, digeſtion, and tranquil bowels, than the artifices of cookery, or than forced, coſtly, and far-fetched dainties?

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

It is not neceſſary to contend, that the advantages derived from wealth are none, (under due regulations they are certainly conſiderable) but that they are not greater than they ought to be. *Money* is the ſweetener of human toil; the ſubſtitute for coercion; the reconciler of labor with liberty. It is, moreover, the ſtimulant of enterprize in all projects and undertakings, as well as of diligence in the beneficial arts and employments. Now did affluence, when poſſeſſed, contribute nothing to happineſs, or nothing beyond the mere ſupply of neceſſaries; and the ſecret ſhould come to be diſcovered; we might be in danger of loſing great part of the uſes, which are, at preſent, derived to us through this important medium. Not only would the tranquility of ſocial life be put in peril by the want of a motive to attach men to their private concerns; but the ſatisfaction which all men receive from ſucceſs in their reſpective occupations, which collectively conſtitutes the great maſs of human comfort, would be done away in its very principle.

With reſpect to *ſtation*, as it is diſtinguiſhed from riches, whether it confer authority over others, or be inveſted with honors which apply ſolely to ſentiment and imagination, the truth is, that what is gained by riſing through the ranks of life, is not more than ſufficient to draw forth the exertions of thoſe who are engaged in the purſuits which lead to advancement, and which, in general, are ſuch as ought to be encouraged. Diſtinctions of this ſort are ſubjects much more of competition than of enjoyment: and in that competition their uſe conſiſts. It is not, as hath been rightly obſerved, by what the *Lord Mayor* feels in his coach, but by what the *apprentice* feels who gazes at him, that the public is ſerved.

As we approach the ſummits of human greatneſs, the compariſon of good and evil, with reſpect to perſonal comfort, becomes ſtill more problematical; even allowing to ambition all its pleaſures. The poet aſks, "What is grandeur, what is power?" The philoſopher anſwers, "Conſtraint and plague; et in maximâ quâ fortunâ minimum licere." One very common error miſleads the opinion of mankind upon this head, viz that, univerſally, authority is pleaſant, ſubmiſſion painful. In the general courſe of human affairs, the very reverſe of this is nearer to the truth. Command is anxiety, obedience eaſe.

Artificial diſtinctions ſometimes promote real equality. Whether they be hereditary, or be the homage paid to office, or the reſpect attached by public opinion to particular profeſſions, they ſerve to *confront* that grand and unavoidable diſtinction which ariſes from property, and which is moſt overbearing where there is no other. It is of the nature of property, not only to be irregularly diſtributed, but to run into large maſſes. Public laws ſhould be ſo conſtructed as to favor its diffuſion as much as they can. But all that can be done by laws, conſiſtently with that degree of government, over his property which ought to be left to the ſubject, will not be ſufficient to counteract this tendency. There muſt always therefore be the difference between rich and poor; and this difference will be the more grinding, when no pretenſion is allowed to be ſet up againſt it.

So that the evils, if evils they muſt be called, which ſpring either from the neceſſary ſubordinations of civil life, or from the distinctions which have, naturally, though not necessarily, grown up in most societies, so long as they are unaccompanied by privileges 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 occasion to one another, by their private wickednesses and cruelties; by tyrannical exercises of power, by rebellions against just authority, by wars, by national jealousies and competitions operating to the destruction of third countries, or by other instances of misconduct either in individuals or societies, are all to be resolved into the character of man, as a *free agent*. Free agency in its very essence contains liability to abuse. Yet, if you deprive man of his free agency, you subvert his nature. You may have order from him and regularity, as you may from the tides or the trade winds, but you put an end to his moral character, to virtue, to merit, to accountableness, to the use indeed of reason. To which must be added the observation, that even the bad qualities of mankind have an origin in their good ones. The case is this. Human passions are either necessary to human welfare, or capable of being made, and, in a great majority of instances, in fact made, conducive to its happiness. These passions are strong and general; and, perhaps, would not answer their purpose unless they were so. But strength and generality, when it is expedient that particular circumstances should be respected, become, if left to themselves, excess and misdirection. From which excess and misdirection the vices of mankind (the causes, no doubt, of much misery) appear to spring. This account, whilst it shews us the principle of vice, shews 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 the aids of religion; and that, without having recourſe to any native gratuitous malignity in the human conſtitution. Mr. Hume in his poſthumous dialogues, aſſerts, indeed, of *idleneſs* or averſion to labour (which he ſtates to lie at the root of a conſiderable part of the evils which mankind ſuffer) that it is ſimply and merely bad. But how does he diſtinguiſh 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 dangerous, as an inceſſant, univerſal, indefatigable activity. In the civil world as well as in the material, it is the *vis inertiæ* which keeps things in their order.

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 meeting might be most unfortunate, though the errands, upon which each party set out upon his journey, were the most innocent or the most laudable. The bye 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 acts 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 and 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 of 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 information 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 labour may be *allotted.* Taſks and burthens 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 dependance 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. 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. Uncertainty, therefore, has its use even to those who sometimes complain of it the most.—Seasons of scarcity themselves are not without their advantages; the most conducive to health, to virtue, to enjoyment. They call forth new exertions; they set contrivance and ingenuity at work; they give birth to improvements in agriculture and œconomy; they promote the investigation and management of public resources.

Again; there are strong intelligible reasons, why there 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 the 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 to take place from the beginning of life, must, ex hypothesi, be previous to the merit or demerit of the persons upon which it falls, can it be better disposed of than 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 it should seem, of a still more necessary rule, that the low 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 shewn, for the poor, that is, they who seek their subsistence by constant manual labour, must still form the mass of the community; otherwise the necessary labour of life could not be carried on; the work would 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 also to be 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 dullness, 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 apparently 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 labour 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 the 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 alledge, 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 distributed 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 endeavouring 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 judgment is that, which regards it as a state of *probation*. If the course of the world were 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 connexion, led to believe, that the appearance, under which events take place, is reconcileable with the supposition of design on the part of the Deity. It is enough that they be reconcileable with this supposition (and it is undoubtedly true, that they may be reconcileable, 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 bro't 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 endeavouring 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 with 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 favoring 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 probable they become. 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 ſhewn 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-India 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 upon the choice and voluntary conduct of thoſe about him, than it does, or ought to do, under regular civil inſtitutions, and the coercion of public laws. So again, to turn our eyes to the other end of the ſcale, namely, that part of it, which is occupied by mankind, enjoying the benefits of learning, together with the lights of revelation, there alſo, the advantage is all along *probationary*. Chriſtianity itſelf, I mean the revelation of Chriſtianity, is not only a bleſſing but a trial. It is one of the diverſified means by which the character is exerciſed; and they who require of Chriſtianity, that the revelation of it ſhould be univerſal, may poſſibly be found to require, that one ſpecies of probation ſhould be adopted, if not to the excluſion of others, at leaſt to the narrowing of that variety which the wiſdom of the Deity hath appointed to this part of his moral œconomy.*

Now if this ſuppoſition be well founded; that is, if it be true, that our ultimate, or our moſt permanent happineſs, will depend, not upon the temporary con-

* The reader will obſerve, that I ſpeak of the revelation of Chriſtianity as diſtinct from Chriſtianity itſelf. The *diſpenſation* may already be univerſal. That part of mankind which never heard of Chriſt's name, may nevertheleſs be redeemed, that is, be placed in a better condition with reſpect to their future ſtate, by his intervention; be the objects of his benignity and interceſſion, as well as of the propitiatory virtue of his paſſion. But this is not "natural Theology," therefore I will not dwell longer upon it.

dition into which we are caſt, but upon our behavior in it; then is it a much more fit ſubject of *chance* than we uſually allow or apprehend it to be, in what manner, the variety of external circumſtances, which ſubſiſt in the human world, is diſtributed amongſt the individuals of the ſpecies. "This life being a ſtate of probation, it is immaterial," ſays Rouſſeau, "what kind of trials we experience in it, provided they produce their effects." Of two agents, who ſtand indifferent to the moral Governor of the univerſe, one may be exerciſed by riches, the other by poverty. The treatment of theſe two ſhall appear to be very oppoſite, whilſt in truth it is the ſame: for, though in many reſpects, there be great diſparity between the conditions aſſigned, in one main article there may be none, viz. in that they are alike trials; have both their duties and temptations, not leſs arduous or leſs dangerous, in one caſe than the other: ſo that, if the final award follow the character, the original diſtribution of the circumſtances under which that character is formed, may be defended upon principles not only of juſtice but equality. What hinders, therefore, but 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 an inequality of concredited talents here, as well, probably, as an inequality of conditions hereafter, though all remuneratory, can any rule, adapted to that inequality, be more agreeable even to our apprehensions of distributive justice, than this is?

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

Passive virtues, of all others the severest and the most sublime; of all others, perhaps, the most acceptable to the Deity; would, it is evident, be excluded from a constitution, in which happiness and misery regularly followed virtue and vice. Patience and composure under distress, affliction, and pain; and steadfast keeping up of our confidence in God, and of our reliance upon his final goodness, at the time when every thing present is adverse and discouraging; and (what is no less difficult to retain) a cordial desire for the happiness of others, even when we are deprived of our own: these dispositions, which constitute, perhaps, the perfection of our moral nature, would not have found their proper office and object in a state of avowed retribution; and in which, consequently, endurance of evil would be only submission to punishment.

Again; one man's sufferings may be another man's trial. The family of a sick parent is a school of filial piety. The charities of domestic life, and not only these, but all the social virtues, are called out by distress. But then, misery, to be the proper object of mitigation, or of that benevolence which endeavors to relieve, must be really or apparently casual. It is upon such sufferings alone that benevolence can operate. For were there no evils in the world, but what were punishments, properly and intelligibly such, benevolence would only stand in the way of justice. Such evils, consistently with the administration of moral government, could not be prevented or alleviated, that is to ſay, could not be remitted in whole or in part, except by the authority which inflicted them, or by an appellate or ſuperior authority. This conſideration, which is founded in our moſt acknowledged apprehenſions of the nature of penal juſtice, may poſſeſs its weight in the Divine councils. Virtue perhaps is the greateſt of all ends. In human beings relative virtues form a large part of the whole. Now relative virtue preſuppoſes, not only the exiſtence of evil, without which it could have no object, no material to work upon, but that evils be, apparently at leaſt, *misfortunes;* that is, the effects of apparent chance. It may be in purſuance, therefore, and in furtherance of the ſame ſcheme of probation, that the evils of life are made ſo to preſent themſelves.

I have already obſerved that, when we let in religious conſiderations, we often let in light upon the difficulties of nature. So in the fact now to be accounted for, the *degree* of happineſs, which we uſually enjoy in this life, may be better ſuited to a ſtate of trial and probation, than a greater degree would be. The truth is, we are rather too much delighted with the world, than too little. Imperfect, broken, and precarious as our pleaſures are, they are more than ſufficient to attach us to the eager purſuit of them. A regard to a *future* ſtate can hardly keep its place as it is. If we were deſigned therefore to be influenced by that regard, might not a more indulgent ſyſtem, a higher, or more uninterrupted ſtate of gratification, have interfered with the deſign? At leaſt it ſeems expedient, that mankind ſhould be ſuſceptible of this influence, when preſented to them; that the condition of the world ſhould not be ſuch, as to exclude its operation, or even to weaken it more than it does. In a religious view (however we may complain of them in every other) privation, diſappointment, and ſatiety, are not without the moſt ſalutary tendencies.

CHAPTER XXVII.

CONCLUSION.

In all cafes, wherein the mind feels itfelf in danger of being confounded by variety, it is fure to reft upon a few ftrong points, or perhaps upon a fingle inftance. Amongft a multitude of proofs, it is one that does the bufinefs. If we obferve in any argument, that hardly two minds fix upon the fame inftance, the diverfity of choice fhews the ftrength of the argument, becaufe it fhews the number and competition of the examples. There is no fubject in which the tendency to dwell upon felect or fingle topics is fo ufual, becaufe there is no fubject, of which, in its full extent, the latitude is fo great, as that of natural hiftory applied to the proof of an intelligent Creator. For my part, I take my ftand in human anatomy: and the examples of mechanifm I fhould be apt to draw out from the copious catalogue which it fupplies, are the pivot upon which the head turns, the ligament within the focket of the hip joint, the pulley or trochlear mufcle of the eye, the epiglottis, the bandages which tie down the tendons of the wrift and inftep, the flit or perforated mufcles at the hands and feet, the knitting of the inteftines to the mefentery, the courfe of the chyle into the blood, and the conftitution of the fexes as extended throughout the whole of the animal creation. To thefe inftances, the reader's memory will go back, as they are feverally fet forth in their places: there is not one of the number which I do not think decifive; not one which is not ftrictly mechanical: nor have I read or heard of any folution of thefe appearances, which, in the fmalleft degree, fhakes the conclufion that we build upon them.

But, of the greateft part of thofe, who, either in this book or any other, read arguments to prove the exiftence of a God, it will be ſaid, that they leave off only where they began; that they were never ignorant of this great truth, never doubted of it; that it does not therefore appear, what is gained by reſearches from which no new opinion is learnt, and upon the ſubject of which no proofs were wanted. Now I anſwer, that, by *inveſtigation*, the following points are always gained, in favor of doctrines even the moſt generally acknowledged, (ſuppoſing them to be true,) viz. ſtability and impreſſion. Occaſions will ariſe to try the firmneſs of our moſt habitual opinions. And, upon theſe occaſions, it is a matter of incalculable uſe to feel our foundation; to find a ſupport in argument for what we had taken up upon authority. In the preſent caſe, the arguments upon which the concluſion reſts, are exactly ſuch, as a truth of univerſal concern ought to reſt upon. "They are ſufficiently open to the views and capacities of the unlearned, at the ſame time that they acquire new ſtrength and luſtre from the diſcoveries of the learned." If they had been altogether abſtruſe and recondite, they would not have found their way to the underſtanding of the maſs of mankind; if they had been merely popular, they might have wanted ſolidity.

But, ſecondly, what is gained by reſearch in the ſtability of our concluſion, is alſo gained from it in *impreſſion* Phyſicians tell us, that there is a great deal of difference between taking a medicine, and the medicine getting into the conſtitution. A difference not unlike which, obtains with reſpect to thoſe great moral propoſitions, which ought to form the directing principles of human conduct. It is one thing to aſſent to a propoſition of this ſort; another, and a very different thing, to have properly imbibed its influence. I take the caſe to be this. Perhaps almoſt every man living has a particular train of thought, into which his mind falls, when at leiſure from the impreſſions and ideas that occasionally excite it: perhaps also, the train of thought here spoken of, more than any other thing, determines the character. It is of the utmost consequence, therefore, that this property of our constitution be well regulated. Now it is by frequent or continued meditation upon a subject, by placing a subject in different points of view, by induction of particulars, by variety of examples, by applying principles to the solution of phænomena, by dwelling upon proofs and consequences, that mental exercise is drawn into any particular channel. It is by these means, at least, that we have any power over it. The train of spontaneous thought, and the choice of that train, may be directed to different ends, and may appear to be more or less judiciously fixed, according to the purpose, in respect of which we consider it: but, in a *moral view*, I shall not, I believe, be contradicted when I say, that, if one train of thinking be more desirable than another, it is that which regards the phænomena of nature with a constant reference to a supreme intelligent Author. To have made this the ruling, the habitual sentiment of our minds, is to have laid the foundation of every thing which is religious. The world from thenceforth becomes a temple, and life itself one continued act of adoration. The change is no less than this, that, whereas formerly God was seldom in our thoughts, we can now scarcely look upon any thing without perceiving its relation to him. Every organized natural body, in the provisions which it contains for its sustentation and propagation, testifies a care on the part of the Creator expressly directed to these purposes. We are on all sides surrounded by such bodies; examined in their parts, wonderfully curious; compared with one another, no less wonderfully diversified. So that the mind, as well as the eye, may either expatiate in variety and multitude, or fix itself down to the investigation of particular divisions of the science. And in either case it will rise up from its occupation, possessed by the subject, in a very different manner, and with a very different degree of influence, from what a mere assent to any verbal proposition which can be formed concerning the existence of the Deity, at least that merely complying assent with which those about us are satisfied, and with which we are too apt to satisfy ourselves, can or will produce upon the thoughts. More especially may this difference be perceived, in the degree of admiration and of awe, with which the Divinity is regarded, when represented to the understanding by its own remarks, its own reflections, and its own reasonings, compared with what is excited by any language that can be used by others. The works of nature want only to be contemplated. When contemplated, they have every thing in them which can astonish by their greatness: for, of the vast scale of operation, through which our discoveries carry us, at one end we see an intelligent Power arranging planetary systems, fixing, for instance, the trajectory of *Saturn*, or constructing a ring of a hundred thousand miles diameter, to surround his body, and be suspended like a magnificent arch over the heads of his inhabitants; and, at the other, bending a hooked tooth, concerting and providing an appropriate mechanism, for the clasping and reclasping of the filaments of the feather of a 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 connexion of system, from Saturn to our own globe; and when arrived upon our own globe, we can, in the second place, pursue the connexion 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 hands. 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 *earwig*, 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 must 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 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 and myſterious 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 philoſoper; 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 œconomy 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, without doubt, 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 infect 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 shew, that, even in the observable course of nature, organizations are formed one beneath another; and, amongst a thousand other instances, it shews completely, that the Deity can mold 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 shew, 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 (probably 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 prepare; under a firm and settled persuasion, that, living and dying, we are his; that life is passed in his constant presence, that death resigns us to his merciful disposal.

* See Search's Light of Nature, passim.

FINIS.